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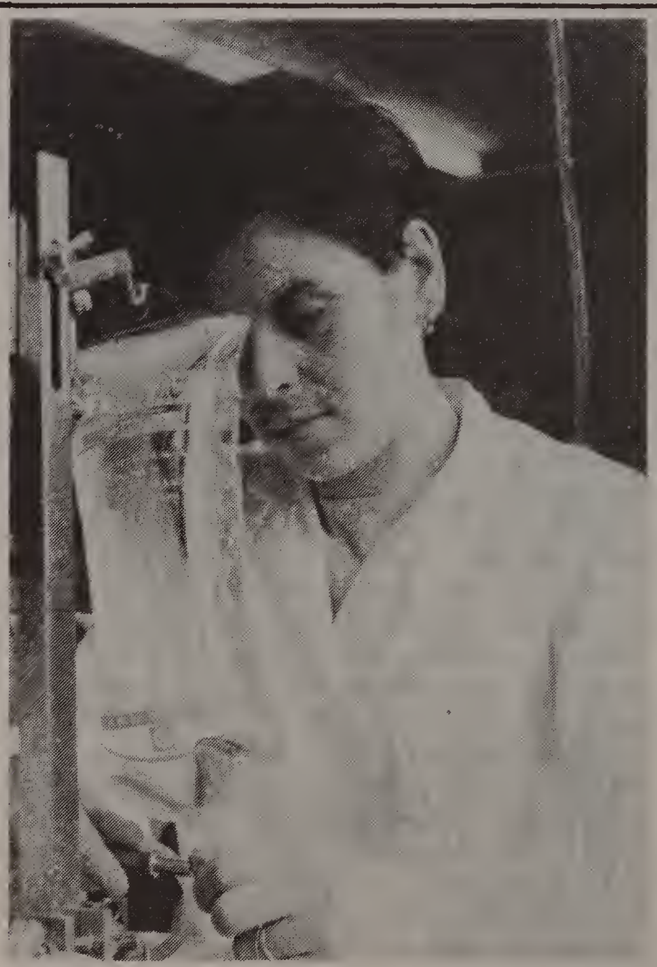
New programs seek effective, low-cost drugs for the Third World

A program of applied health research is being undertaken by the World Health Organization with the goal of providing basic medical services to all the world's population by the year 2000. Despite phenomenal strides in medical technology which have benefited people in industrialized nations, health services in most of Asia, Africa and Latin America are still only comparable with those in industrialized nations at the end of the last century. Less than 10% of the children born in developing countries now benefit from immunization. Of the estimated 1.5 billion children in the world today, 81% live in developing countries, many in an environment of malnutrition, lack of safe water, and inadequate (or non-existent) health care. An estimated 122 million children were born in 1978, and 10-12 million died before their first birthday.

The World Health Organization is focussing its efforts on several major diseases, trying to develop improved and inexpensive pharmaceutical preparations, transportation methods and effective local administrative systems. It is hoped that by 1990, every child can be vaccinated against diphtheria, whooping cough, tetanus, measles, polio and tuberculosis. Together, these six diseases kill 5 million children each year, and leave a similar number crippled, blind or mentally retarded. Using improved carriers to transport vaccines, optimal use of syringes and jet injectors, and locally-trained personnel, full immunization of a child against these diseases should cost about US$3 during the coming decade. Half will need to come from outside contributions (for vaccines and equipment). To meet this objective, funding provided by donor agencies and governments will need to be increased thirty-fold to some US$150 million per year. By any measure, it would be "cost-effective", requiring about US$30 for each life saved.

Fatalities from diarrhoeal diseases have been nearly eliminated from developed countries in the last century. This is largely due to good medical care and good nutrition. But in the undeveloped world, at least six million deaths occur each year.

Diarrhoea is more common and more deadly than is commonly realized. In developing countries, acute diarrhoea is probably *the* most common cause of death; it is certainly the most common cause of death in small children. Diarrhoea is not rare. According to estimates of the World Health Organization, there were about 500 million cases of diarrhoea among children below 5 years of age in Asia, Africa and Latin America in 1975. Only a small fraction of acute diarrhoea cases result from epidemics of chlorea, typhoid and shigellosis. In Latin America, diarrhoeal diseases cause 30% of all deaths among children below 5 years of age. Furthermore, malnutrition is often initiated by acute diarrhoea, and aggravated by each subsequent attack.



Loss of life from cholera can be greatly reduced in Third World Countries by a simple and cheap pharmaceutical treatment. Rehydration fluid, shown here being packed into plastic bags, can be administered orally by the patient's family. It averts severe (and sometimes, fatal) dehydration brought about by cholera and other diahorreal diseases. Traditional treatment with intravenous solution requires medical supervision and equipment that is often not available in remote or poor areas. *(Photo courtesy of World Health Organization.)*

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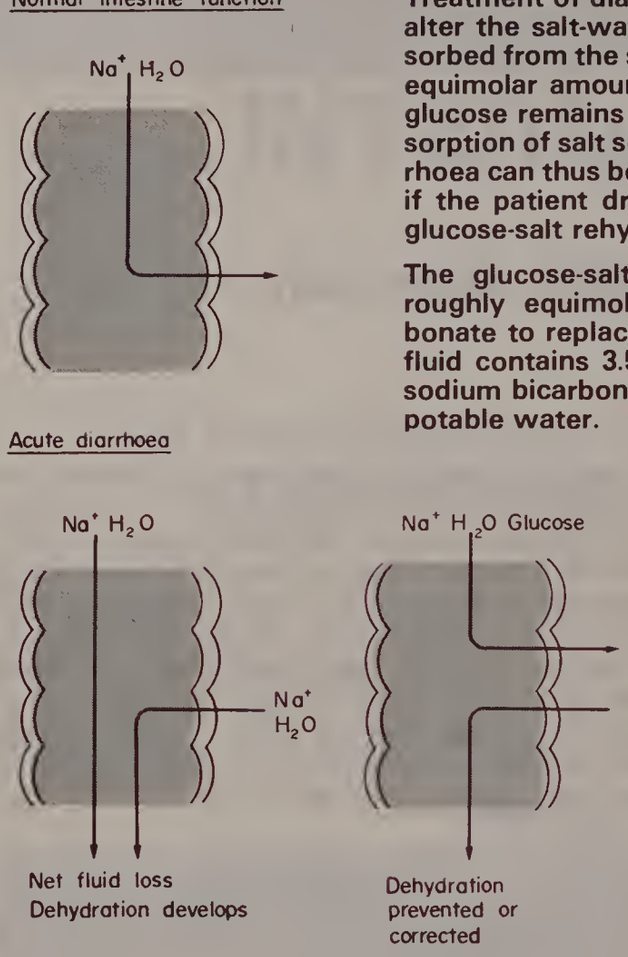


Treatment of diarrhoea with oral rehydration fluid utilizes glucose to alter the salt-water balance in the intestine. Glucose is actively absorbed from the small intestine, and sodium is carried with it in about equimolar amounts. The enhanced absorption of salt solution with glucose remains largely unaffected by acute diarrhoea, although absorption of salt solution alone is greatly impaired. Fluid loss from diarrhoea can thus be halted before reaching a dangerous (or fatal) extent if the patient drinks large amounts (as much as one litre/hour) of glucose-salt rehydration fluid.

The glucose-salt solution should contain sodium and glucose in roughly equimolar amounts, and sufficient potassium and bicarbonate to replace losses. A widely tested and effective rehydration fluid contains 3.5 grams of table salt, 20 grams glucose, 2.5 grams sodium bicarbonate and 1.5 grams potassium chloride in one litre of potable water.

Other sugars which yields glucose upon hydrolysis in the gut can be substituted for glucose. Rehydration fluid containing 40 grams/litre of sucrose (cane sugar) was found to be nearly as effective. Even during acute diarrhoea, the intestine retains the ability to absorb a variety of nutrients. A notable exception is lactose (milk sugar). Patients with diarrhoea should continue to eat and drink normal foods, but consumption of cow's milk might need to be reduced or stopped. (This diagram is adapted from the excellent review article *Oral fluid—a simple weapon against dehydration in diarrhoea,* published in *WHO Chronicle,* 31 (1977)87 .

While poor nutrition and inadequate sanitary facilities continue to perpetuate diarrhoeal diseases, the toll in human lives can be drastically cut by highly effective medical treatments now available. The primary danger from acute diarrhoea is dehydration: the body is unable to absorb most liquids from the digestive tract. Direct administration of solutions into the bloodsteam by intravenous injection effectively prevents dehydration, but this relatively expensive treatment requires trained health workers at a clinic or hospital. Because of this, treatment is often not begun until symptoms of serious dehydration have developed.

Now however, a rehydration fluid has been developed which is absorbed *directly from the digestive tract,* and can be administered by family members at home with minimal medical supervision. The solution is made by dissolving inexpensive components (sodium chloride, glucose, sodium bicarbonate, and potassium chloride) in water. A global program to treat diarrhoeal diseases by oral rehydration has been started with a US$1 million contribution from the United Kingdom and Northern Ireland.

Oral rehydration has already been demonstrated as a highly effective, life-saving treatment. It can successfully replace intravenous fluid treatment in all but a few cases (primarily, when treatment has been delayed and severe dehydration has already occurred). When cholera and infantile diarrhorea were treated by experienced health workers, there was almost no mortality and the need for intravenous fluids was reduced by 70-90%. Even when oral rehydration was used under the worst possible conditions to treat cholera among Bangladesh refugees, mortality was only 3%, and half of these deaths occurred before treatment could be given.

Could oral rehydration therapy gain wide use in the industrialized world as well? The Czechoslovak Academy of Sciences Institute of Pharmacology has reported "remarkable" results in treating diarrhoeal diseases in calves, and the method offers some advantages over intravenous rehydration treatment, now standard in medically-advanced nations. Oral rehydration is "non-invasive" and avoids the possibility of hepatitis or other complications which occasionally arise from intravenous injection. In fact, oral rehydration may provide an interesting precedent for the development of other low-cost, but highly-effective, medical treatments.

These and other efforts to improve global health conditions are discussed in the second newsletter of the World Health Organization, entitled *OMS Action WHO* (OMS is the abbreviated French translation, Organisation Mondiale de la Santé). It provides examples of proposed WHO projects which have been researched and await funding for implementation. These vary from programs requiring a few thousand dollars, to those costing several million. Examples include: development of teaching material for radiological technicians working in isolated areas of developing countries (to be translated into several languages); a

regional program to prevent acute rheumatic fever in schoolchildren in South-East Asia, where the disease is still prevalent; and inter-country programs for the prevention and control of buco-pharyngeal and naso-pharyngeal cancer. A complete catalog of projects has been prepared, and is available from the Cooperative Programmes for Development, Division of Coordination, World Health Organization, 1211 Geneva 27, Switzerland.

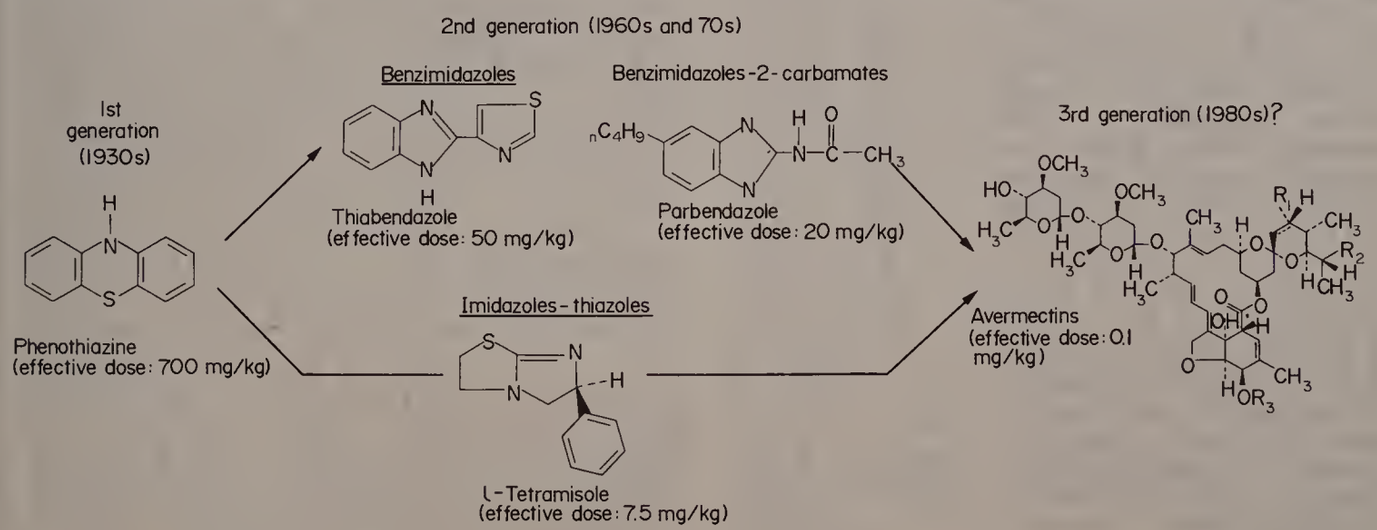
A global affliction may be relieved by novel treatment methods

Worm parasites are one of the most prevalent health problems. Flukes, tapeworms and roundworms (collectively termed "helminths") infest an estimated 200 million people in tropical countries, and are a serious menace for domestic animals. They presently cause immeasurable suffering and disability among human victims, and cost farmers hundreds of millions of dollars in reduced meat production and quality, dead animals and control measures.

A new series of anthelminthic agents have recently been developed which exhibit extraordinary activity against a wide range of worm parasites. If further testing verifies the unparalleled activity of avermectin compounds and their low toxicity to animals and humans, they could significantly reduce damage and misery caused by worm parasites.

Avermectins are a family of similar compounds unrelated to any drugs previously used for the control of worms. They are a natural fermentation product of a species of actinomycete bacteria *Streptomyces avermitilis,* originally obtained from soil collected at Ito City, Japan. Samples were analyzed at the Merck, Sharp & Dohme Laboratories in Rahway, New Jersey (USA), where bacterial broth was found effective against a variety of roundworms in mice. Active compounds in the broth were subsequently isolated and identified as a family of complex multi-ringed compounds. Individual avermectin components are active against a variety of parasitic worms. A single dose of about 100 mg of Avermectin B_{1a}(0.1 mg/kg body weight) kills more than 95% of gastrointestinal roundworms in cattle. Equal effectiveness was attained in sheep infested with a variety of worm parasites. Hookworms in dogs were killed at a dosage of only 0.005 mg/kg body weight. No other anthelminthic agents approach the potency and wide spectrum of biological activity found so far by preliminary testing of avermectin compounds. They destroy parasitic worms with only 1/30th dosage usually required for the most active conventional drugs.

The development of anthelminthic drugs provides an interesting chemical history, reviewed in an article by Mr. A. A. Baklien and published in the May 1979 issue of *Chemistry in Australia.* The article begins with the revolutionary introduction of *phenothiazine* in the late 1930's. It was the first effective anthelminthic drug, and was so much better than anything used before that it became the primary



Drugs for the control of worm parasites are limited to derivatives of a few basic compounds. Phenothiazine was the first effective anthelmintic compound, and revolutionized the treatment of worm parasites in humans and animals. Twenty five years later, derivatives of Benzimidazole and Imidazole-Thiazoles achieved similar effectiveness at only 1/20th the dosage. Now, an entirely new class of anthelmintic compounds—the avermectins—is on the horizon. They promise more effective treatment at lower cost. The dosage required to kill worm parasites in test animals is two orders of magnitude lower than presently-available anthelmintics.

agent for the control of worm parasites. However, large doses were required (600-800 mg/kg body weight), and this limitation ultimately led chemists to seek more potent compounds.

The second generation of anthelminthics began with Merck's introduction of *thiabendazole* in 1961. It was effective against a wide range of worms at dosage of 50 mg/kg, but was still limited to control of gastrointestinal parasites. *Thiabendazole* was the fore-runner of a series of benzimidazole therapeutic agents. By substituting side chains on the thiabendazole backbone structure, other compounds of higher activity were synthesized.

At the same time that Merck, Sharp & Dohme were developing *thiabendazole,* ICI was synthesizing and testing benzimidazole compounds in Australia. They produced *phenzidole,* which had comparable activity and lower cost than *thiabendazole,* and marketed it in Australia, New Zealand and South America.

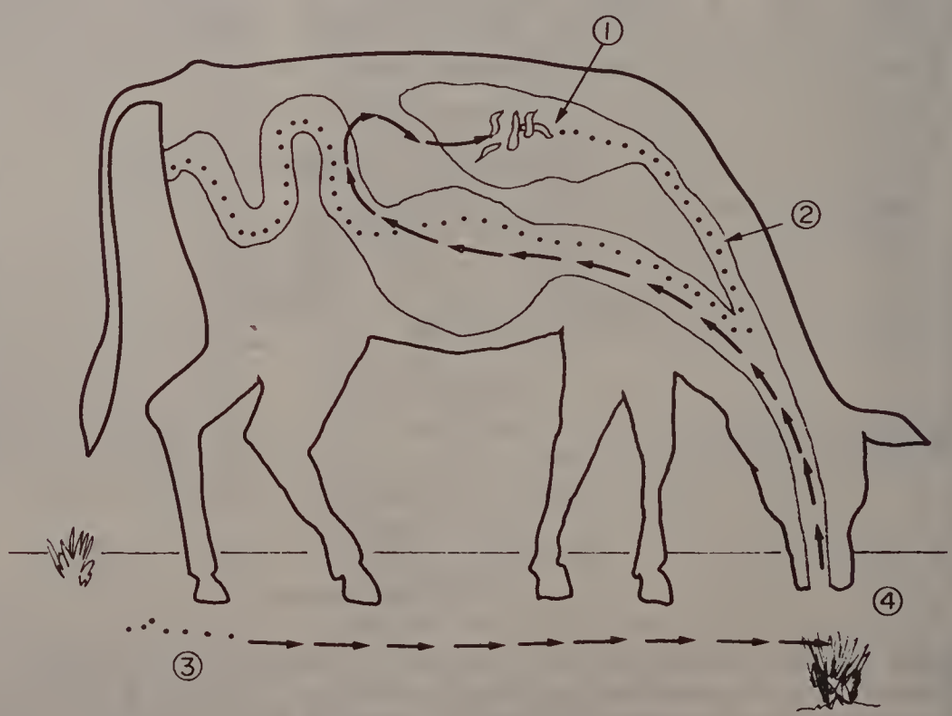
It was soon found that *thiabendazole* and *phenzidole* are metabolized in the body by hydroxylation in the 5 position of the ring backbone. The 5-hydroxy products are inactive, and excreted from the body. To prevent metabolism, attempts were made to block hydroxylation by placing other substituents in the vulnerable 5 position of the benzimidazole structure. Attachment of an isopropyl group through a peptide linkage increased biological activity to 2½ times that of the parent compound. Even more effective drugs were made by placing substituents on the 5 position of benzimidazole-2-carbamate. Insertion of an *n*-butyl group gives rise to *parbendazole,* the first of a group of benzimidazole-2-carbamate derivatives.

Meanwhile, Janssen Pharmaceutical Company (in Belgium) was testing a different group of heterocyclic compunds, the imidazole-thiazoles. An important member of this group is *tetramisole,* which is effective against gastrointestinal worms and lungworms at 15 mg/kg dosage. It was later discovered that only the *l-tetramisole* isomer was active against worms, while both *d* and *l* optical isomers (present in equal amounts) had similar toxicity to animals. The use of pure *l-tetramisole* therefore offerred two outstanding advantages: a halving of the required dose, and a doubling of the safety margin. As a result, ICI Australia built a commercial plant to separate the two drug isomers - the second such plant ever built. Relatively few imidazole-thiazole compounds have high activity. Unlike the benzimidazole agents (of which over 250 were made), activity of imidazole-thiazoles is generally reduced by substitution on the ring backbone or other modifications of the molecular structure.

It is surprising that modern anthelminthic

The life cycle of cattle lungworms parallels that of some human worm parasites. (1) Adult worms (about 2-5 cm long) lay eggs in the lung of an infected animal (2). Eggs are coughed up and swallowed. They hatch into larvae in the gut and are passed in faeces. In the soil (3), larvae develop into the infective stage, and are eaten with foliage by other animals (4). The infective larvae penetrate the intestines and are carried by the blood to the lungs, where they reach adulthood.

The disease may be controlled with benzimidazole derivatives, or calves may become naturally immune when exposed to mild pasture contamination. The animal's immune response develops when the larvae are maturing to adulthood in the lungs. The mechanism of immunity is not yet clear, but it appears to be localized in the lung tissue. The same immune response is elicited by vaccination with live larvae which have been subjected to X-ray irradiation. They reach the lung, but do not mature into adult worms or inflict harm.



The effectiveness of the vaccine has been confirmed by extensive field experience. It has now been used successfully to vaccinate several million calves, and its use is steadily increasing. *(Diagram adapted from "Parasitic Bronchitis", a 30-page guide to treatment and prevention of parasitic lungworms, published by Glaxovet Ltd in the UK, distributors of the vaccine.)*

drugs have been limited to only two main groups: benzimidazoles and imidazole-thiazoles. Until the recent discovery of avermectins, it appeared that improvement in activity had reached an impasse. Benzimidazoles have been a versatile group of anthelminthic drugs, but there is now widespread resistance to them, and some carbamate derivatives are suspected of inducing genetic mutations or tumors. It is unlikely that further major advances will arise from the second generation anthelminthic drugs. The future rests in the development of a totally new generation of pharmaceuticals which now appears on the horizon.

Control of worm infestation might also be achieved through an entirely different route: vaccination. For twenty years, young calves have been vaccinated against lungworm in several parts of Europe. The vaccine is produced by subjecting worm larvae to nuclear radiation. The radiation does not kill the larvae, so they still stimulate the animal's immune system. The irradiated larvae, however, are no longer capable of developing in the animal.

The vaccines now being used were developed by the Veterinary School at the University of Glasgow (Scotland) and are manufactured by Glaxovet Ltd. in Britain. A present limitation of lungworm vaccine is its short shelf-life.

The life cycle of the lungworm is relatively simple, and lends itself readily to control by "radiation-attenuated" vaccines. Development of new vaccines against local strains of sheep and cattle lungworm is now being pursued in India, Brazil and Ethiopia. Research on radiation-attenuated vaccines is being conducted jointly by the United Nations Food and Agriculture Organization and the International Atomic Energy Agency.

Good news about carbon monoxide

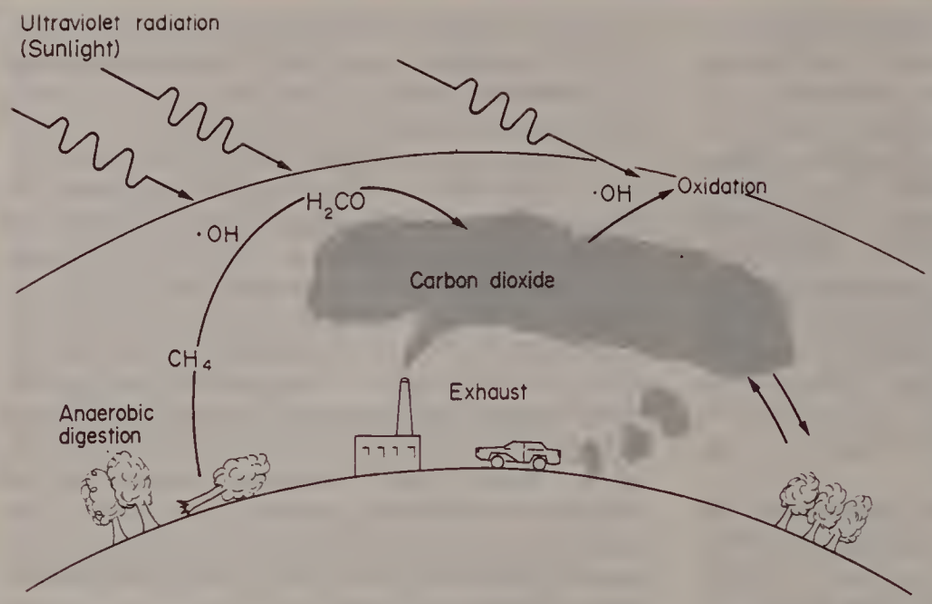
Each year, about 500 million tonnes of carbon monoxide stream into the atmosphere from motor vehicle exhaust and smokestacks, more than any other toxic pollutant. Carbon monoxide concentrations in areas of congested automobile traffic can exceed 500 ppm, enough to cause headache and dizziness. Yet, carbon monoxide has *not* been accumulating throughout the atmosphere, as is reasonable to expect. In fact, recent studies show that levels of carbon monoxide in the Arctic and Antarctica are the same now as they have been for hundreds of years.

Attempts to explain why CO concentrations have not been rising have resulted in the discovery of natural processes that create and destroy carbon monoxide. An unexpected result has emerged: while man-made emissions create high *local concentrations* of CO, the largest *total* release of CO is from natural sources. Many were previously unknown or unsuspected.

A small (relatively insignificant) amount of carbon monoxide is produced by living animals, including man. A healthy person exhales about 1 ppm carbon monoxide in his breath. It apparently originates from the normal decomposition of haemoglobin. People with the rare disorder of haemolytic anemia break down haemoglobin at a much faster rate, and can exhale nearly ten times as much carbon monoxide. However, carbon monoxide exhalation by the total human population is only about 0.004% that released by combustion of hydrocarbon fuels.

The most important source of carbon monoxide appears to be the breakdown of methane in the atmosphere. At least three times as much carbon monoxide is released in this way as by man-made pollution. Methane is naturally present in the air (at about 1.4 ppm in clean mountain air), originating from bacterial breakdown of dead organic matter in the absence of oxygen.

It is believed that methane reacts with OH radicals formed by photochemical reactions in the atmosphere. The reaction produces CH_3 radicals, which combine with oxygen to form formaldehyde. Ultraviolet radiation subsequently dissociates formaldehyde molecules to



Carbon monoxide is produced in greatest amounts by natural sources, although automobiles and other man-made emissions are responsible for high local concentrations. One natural source alone, the reaction of methane with hydroxyl radicals in the atmosphere, produces considerably more CO than is emitted from man-made sources. In fact, it appears that the total amount of CO in the atmosphere has not changed in hundreds of years.

HCO, which reacts with oxygen, producing carbon monoxide.

Reaction of methane produces an estimated 1500-5000 million tonnes of carbon monoxide. The exact value is uncertain because inadequate experimental measurements of atmospheric OH densities limit the accuracy of a calculated global average.

Atmospheric hydroxyl radicals probably account for the primary means of destroying carbon monoxide, as well as its formation. Chemistry of the destruction of CO is complex, and its understanding is based largely on theoretical models. Destruction rates calculated by different researchers vary considerably. Much controversy remains, and clarification of the reaction mechanism awaits experimental measurements.

Controversy also centers the destruction of carbon monoxide by plants. Studies of the uptake of isotopically-labelled ^{14}CO by leaves of barley and bean plants suggest that this might be a major process purging carbon monoxide from the atmosphere. Rates of CO uptake varied significantly among different species and with the intensity of sunlight. Results were not always consistent. Experiments by some investigators indicated no uptake of carbon monoxide at all.

According to one study, bean leaves metabolize carbon monoxide to form sucrose and protein in sunlight, but oxidize CO almost completely to carbon dioxide in the dark. Experimental results of these researchers show that vegetation covering one square metre of land can assimilate 260 μg CO per hour. That may not sound significant, but is about as much CO as is present in one cubic metre of "clean" unpolluted air with 0.1-0.15 ppm CO. The total capacity of all vegetation throughout the world to absorb CO has been estimated within the range 650-6500 million tonnes per year, but even this broad range is uncertain.

Vegetation *evolves* carbon monoxide, as well as (apparently) consuming it. Small amounts of CO are released during seed germination and seedling growth. Breakdown of chlorophyll in dying plant matter also releases carbon monoxide, and total annual production of CO by vegetation could amount to 60 million tonnes.That does not include another 60 million tonnes released by forest fires and open burning of agricultural waste.

The exact contribution of these, and several other, CO sources and destruction pathways has yet to be accurately determined. It is one of the topics considered on a continuing basis by SCOPE (Scientific Committee on Problems of the Environment, of the Int'l. Council of Scientific Unions). That group convened a workshop on the "Biogeochemical Cycling of Carbon" in March 1977 in the Federal Republic of Germany. Information and recommendations presented at that workshop have been presented in a 490 page report *The Global Carbon Cycle (SCOPE Report No. 13)*, recently published by John Wiley & Sons, Baffins Lane, Sussex PO19 1UD, UK. The discussion on carbon monoxide was contained in the 28 page chapter written by Dr. Hans-Dieter Freyer.

Important points emerged from that workshop, although there still exists considerable uncertainty about precisely how much carbon monoxide is in the atmosphere, where it comes from, and where it goes. It *has* been consistently reported that the residence time of carbon monoxide in the atmosphere before it is destroyed is about 0.1-0.2 years. The total amount of CO present in the atmosphere at any one time is about 500 million tonnes, roughly one-tenth the total yearly emission from all sources. And finally, although automobiles may be degrading our immediate environments with carbon monoxide, they do not appear to cause long-term global effects.

Wide use of surface chemistry probes require uniform presentation of results

Knowledge of surface chemistry has surged forward following wide application of several new techniques in the last decade. Especially important has been electron spectroscopy, of which about a half dozen techniques have been developed. All use some excitation source—u.v. or X-ray radiation, impacting electrons or ions—to excite atoms or molecules at the surface, or within a shallow layer *adsorbed* onto the surface, or within a shallow layer *below* the surface. Indeed, when talking about "a surface" it may be necessary to define whether one means the "physical surface" (the outermost atomic layer), or "experimental surface" (materials at a sufficiently shallow depth to interact with particles or radiation bombarding the surface).

In electron spectroscopy, surface atoms eject or scatter electrons at well-defined energies determined by energy levels of the atom or molecule. The identity of elements, and information about chemical bonding, is revealed by measuring the energy of electrons leaving the surface. Most techniques can identify elements present at the surface. Some infer the chemical environment of surface atoms by the "chemical shift", the slightly different energies of electrons ejected from atoms of the same element in different chemical environments. Other techniques measure energies of *ions* scattered or ejected from the surface.

Ejected electrons or ions can be focussed, and it is possible to determine how the distribution of elements varies *across* the surface. It is also possible to wear away top layers of the surface by bombardment with an intense ion beam, and study how the composition varies with depth *into* the surface.

One characteristic that makes electron and ion spectroscopy so useful is that ejected particles cannot escape from below a very shallow depth - usually less than 5 nm. Electron and ion spectroscopy are thus true surface techniques.

With intense research activity in electron and ion spectroscopy, a clear need has developed for standardization of terminology. Some terms have been widely used in published papers, while different authors intend slightly different meanings. Furthermore, no standard procedure has been adopted for reporting experimental results so that surface analysis data can be reproduced by other researchers. Precise definitions and standard methods of reporting surface analysis results are suggested in a report prepared by the IUPAC Commission of Microchemical Techniques and Trace Analysis. *Recommendations for Nomenclature, Standard Procedures and Reporting of Experimental Data for Surface Analysis Techniques* is a provisional report. It is based on discussions with about 100 surface analysis specialists, and is published to elicit comments and suggestions from the general chemical community. The five-page report is published in *Pure & Applied Chemistry*. November 1979 issues, on page 2243. Comments on the report can be sent to the chairman of the Commission, who is also one of the authors, Prof. M. Grasserbauer at the Institut für Analytische Chemie und Mikrochemie der Technischen Universität Wein, Getreidemarkt 9, A-1060 Wien, Austria. The two other authors of the report are Prof. G. H. Morrison (Cornell University, USA) and Prof. K. L. Cheng (University of Missouri, USA).

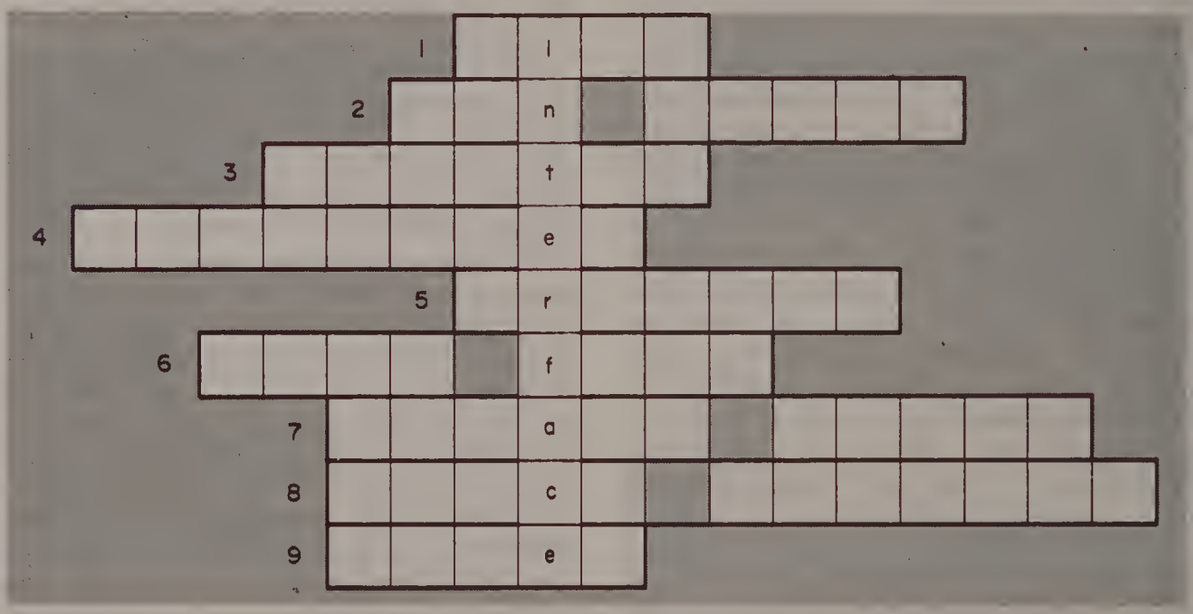
Most terms for which the report recommends standard definitions are already familiar to most surface chemists, electron and ion spectroscopists, and chemists in general. To test your familiarity with surface chemistry terminology, a crossword quiz is presented here. From the definitions provided (most are shortened from those contained in the full nomenclature report), see if you can recollect the correct terms. For a start, one letter appearing in each word is already provided. Answers are provided towards the back of this issue.

Surface scientists form international association

The formation of an International Association of Colloid and Surface Scientists was announced late last year by the group's first president, G. D. Parfitt. The association invites membership from individuals who are actively interested in the field of colloid and interface science. Application forms and further details may be obtained from Dr. H. O. Becker, Institut für Anorganische Chemie der Universität Munchen, Meiserstrasse 1, 8000 Munchen 2, Federal Republic of Germany.

A surface analysis puzzle

Clues given here are adapted from definitions in the report. *Recommendations for Nomenclature, Standard Procedures and Reporting of Experimental Data for Surface Analysis Techniques,* but are not precise definitions.



(1) A technique in which secondary ions (ejected from a surface bombarded by a stream of primary ions) are analyzed in a mass spectrometer (acronym, the first letters of four words).

(2) A microanalysis technique using secondary ion emission for analyzing elements within a small area of surface (less than 10 microns wide) (2 words).

(3) To eject particles from a surface by momentum transfer from impacting ions.

(4) One atomic or molecular layer covering a substrate. Each adsorbed atom or molecule contacts the surface.

(5) Dependence of concentration on depth is called the "depth _____".

(6) A layer of material with a uniform thickness less than about 10 microns.

(7) The depth within which most (63%) of electrons or ions leaving the surface have originated (2 words).

(8) Any element having an average concentration of less than about 100 atoms per million (2 words)

(9) A type of electron spectroscopy in which surface atoms are ionized by a beam of high-energy (keV) electrons, and eject electrons of well-defined energies.

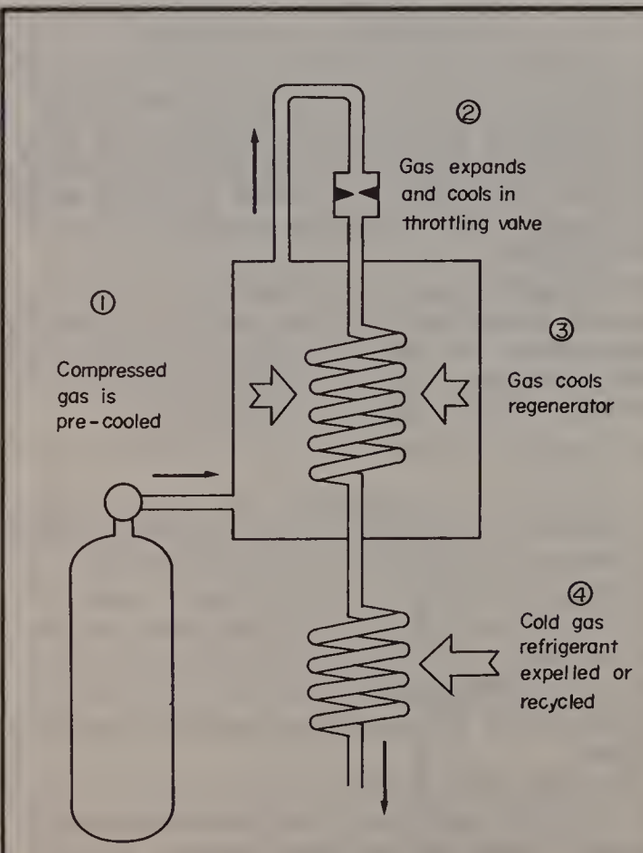
A new invention may open the way for studies of low-temperature chemistry

A Dewar flask filled with liquid nitrogen has become a routine sight in most chemcial laboratories. Because of low cost and wide availability of liquid nitrogen, refrigeration has become one on the simplest and most useful laboratory techniques. However, the world of cryochemistry below 77°K (the boiling point of liquid nitrogen) remains an inaccessible domain to most laboratory chemists. As far as they are concerned, very low temperatures are attainable only by physicists and a few chemists fortunate enough to have sophisticated refrigeration equipment or supplies of liquid helium. This situation could change profoundly. Two physicists at the US National Bureau of Standards have developed a simple, compact refrigerator able to reach temperatures as low as 3°K. After further improvement during the next few years, the device will likely be manufactured. However, the unit is so simple and made of such readily-available materials, the inventors point out, that the device could be made by anyone who has modest skill with a lathe.

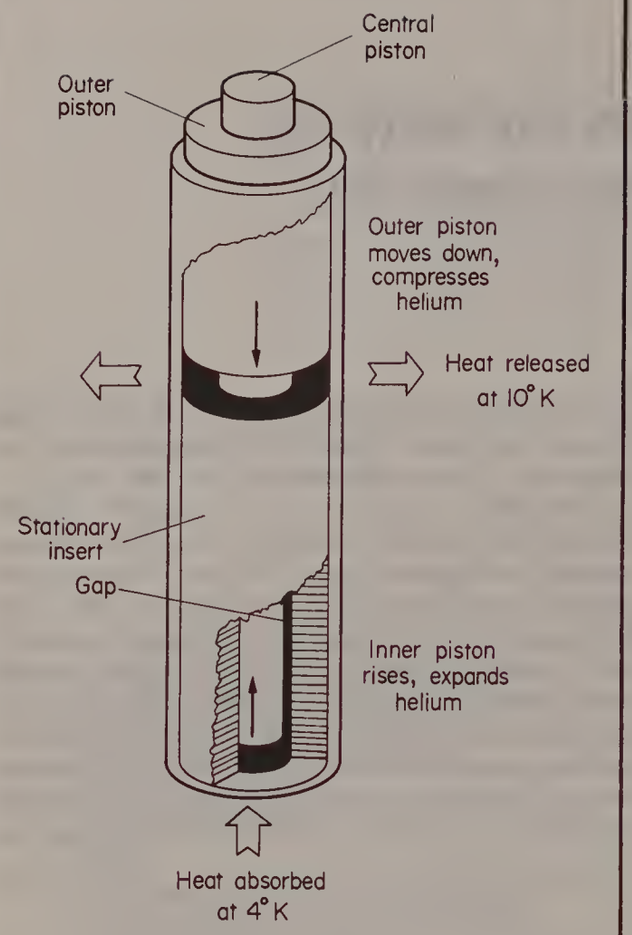
The need for a small, portable cryogenic refrigerator became acutely apparent to Dr. James Zimmerman when he traveled to central Africa and Alaska to make sensitive magnetic field measurements. For his experiments, he needed to cool the instrument sensor to liquid helium temperatures (below 4°K). Dr. Zimmerman soon found that in remote areas supplies of liquid helium were unreliable at best, and could even be difficult to arrange in the continental United States (the world's major supplier of helium). So, in 1977, he set out to design and build a small, simple refrigerator that could cool from room temperature (300°K) to below 4°K, but yet would be no more difficult to transport that a pair of skis.

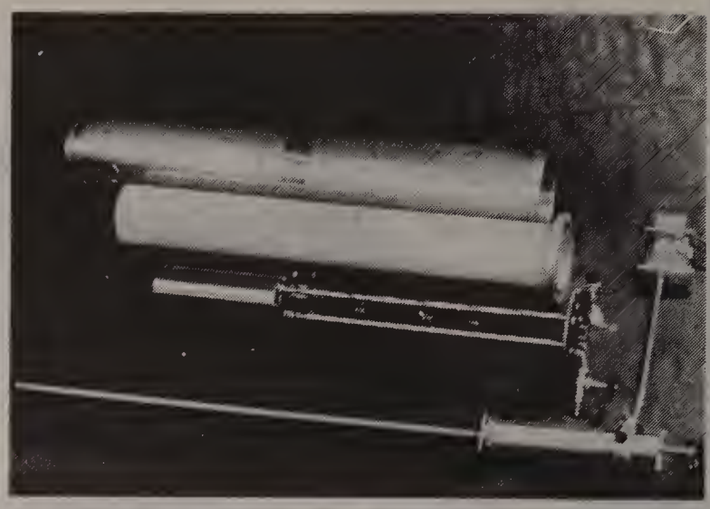
Dr. Zimmerman's cryocooler design was a radical departure from most cryogenic refrigerators. Commercial cryogenic refrigerators almost always utilize a Joule-Thompson cooling cycle, based upon the well-known cooling of a gas as it expands in a nozzle. As the gas expands, its molecules expend energy to overcome the attractive Van der Waals forces of neighboring molecules. A simple one-stage Joule-Thompson device can achieve the 77°K temperature needed to liquefy nitrogen, and additional stages can reduce the temperture to 4°K. In actual practice, Joule-Thompson cryogenic coolers are very inefficient. They achieve only about 0.7% the cooling capacity that is theoretically possible with a given input energy, and even small refrigerators require a minimum power consumption of 500 W.

Departing from the standard Joule-Thompson cooling method. Dr. Zimmerman turned to a Stirling cycle. This was not a completely original or unprecendented idea: the Stirling cycle was first used for refrigeration in 1874, and Stirling cycle refrigerators provide the highest efficiency of all cryocoolers (typically, 3% of the theoretical maximum). During the Stirling cycle, the working gas (only helium can be used at cryogenic temperatures) is alternately expanded and compressed. The helium cools as



Conventional cryogenic refrigerators utilize the cooling of pressurized gas as it expands through a nozzle (Joule-Thompson Effect). The temperature developed by the device falls rapidly when gas begins to flow. Compressed gas entering the system is pre-cooled in the regenerator by the previous flow of expanded gas. After passage through the system, the gas refrigerant is generally compressed back to its original pressure, and recycled. A one-stage Joule-Thompson cycle can develop temperatures low enough to liquefy nitrogen, but the efficiency of refrigeration is very low.





Basic operation of the one-stage Stirling refrigerator is depicted here. A central inner piston, a fiberglass-epoxy rod, slides inside a concentric outer piston. A camshaft (not shown) drives the pistons back-and-forth in a sinusoidal motion, 90° out of phase with one another. Both pistons fit inside a fiberglass-epoxy tube.

In one part of the cycle, shown here, helium gas is trapped and compressed between a stationary insert and the descending outer cylinder. Compression of the gas causes heat to be released into a flange maintained at 8-12°K by the main refrigerator unit. Some of the gas leaks between the pistons to the expanding volume beneath the rising inner piston. Here, expansion of the helium causes it to cool below 4°K.

In the second half of the cycle, when the inner piston moves downward, compression of helium (which would release heat at the cold end of the refrigerator) is avoided by the 90° phase difference between movement of the inner and outer pistons. By the time the inner piston is starting to descend, most of the helium has already been drawn upwards into the expanding volume created by the outer piston.

The part of the device depicted here is only 12 cm long, but the two concentric pistons extend for a metre in length to connecting rods, a crankshaft and a small drive motor—all maintained at room temperature. The entire one-stage device, able to cool to below 4°K is shown in this photograph with a test apparatus which provides "front-end cooling" to 10°K. *(Photograph courtesy of Dr. James Zimmerman, US Nat'l. Bureau of Standards.)*

it expands—not because of the Joule-Thompson effect—but because internal energy of the gas is expended as mechanical work in pushing a piston. Dr. Zimmerman's initial efforts yielded a four-stage Stirling cooler that required only 50 W of input power, yet could reduce the temperature to 8.5°K. This was just short of the 4°K temperature needed to liquefy helium.

To span the last interval from 8.5° to 4°K, Dr. Donald Sullivan assisted in the design of a second "finishing" refrigeration unit. It too is a simple, efficient Stirling-cycle device with no valves, no piston rings, and lubricated only by the helium gas cooling fluid. However, the second refrigerator unit operates with a lower helium pressure (0.3-0.4 atmosphere) than the main refrigerator unit. While high helium pressure was essential for maximum cooling capacity in the first stages of the main refrigerator, the ability to achieve low temperatures mandated the use of low helium pressure in the finishing unit. The one-stage Stirling refrigerator unit requires only a few watts of power from a small electric motor.

With this second refrigeration unit, Drs. Zimmerman and Sullivan could reduce the temperature to as low as 3.1°K, and provide a cooling capacity of 4 mW at 4°K. Both refrigerator units have moving parts made exclusively of fiberglass-epoxy and nylon. These materials do not generate magnetic disturbances that could affect nearby superconducting instruments. Also, the devices operate at low speed (the pistons move about one stroke/second) which results in virtually no vibration.

Those wishing to obtain further information might read "A milliwatt Stirling cryocooler for temperatures below 4°K", published in *Cryogenics,* March 1979, pp. 170-171. A good general discussion of Stirling cryocoolers and refrigeration cycles appears in "Applications of Closed-Cycle Cryocoolers to Small Superconducting Devices", Special Publication 508 of the US Nat'l Bureau of Standards (April 1978). It may be purchased from the Superintendent of Documents, US Govt. Printing Office, Washington D.C. 20434, at a cost of US $4.25 & $1.05 for mailing outside the USA.

Nuclear reactors will provide energy to upgrade chemicals, make steel

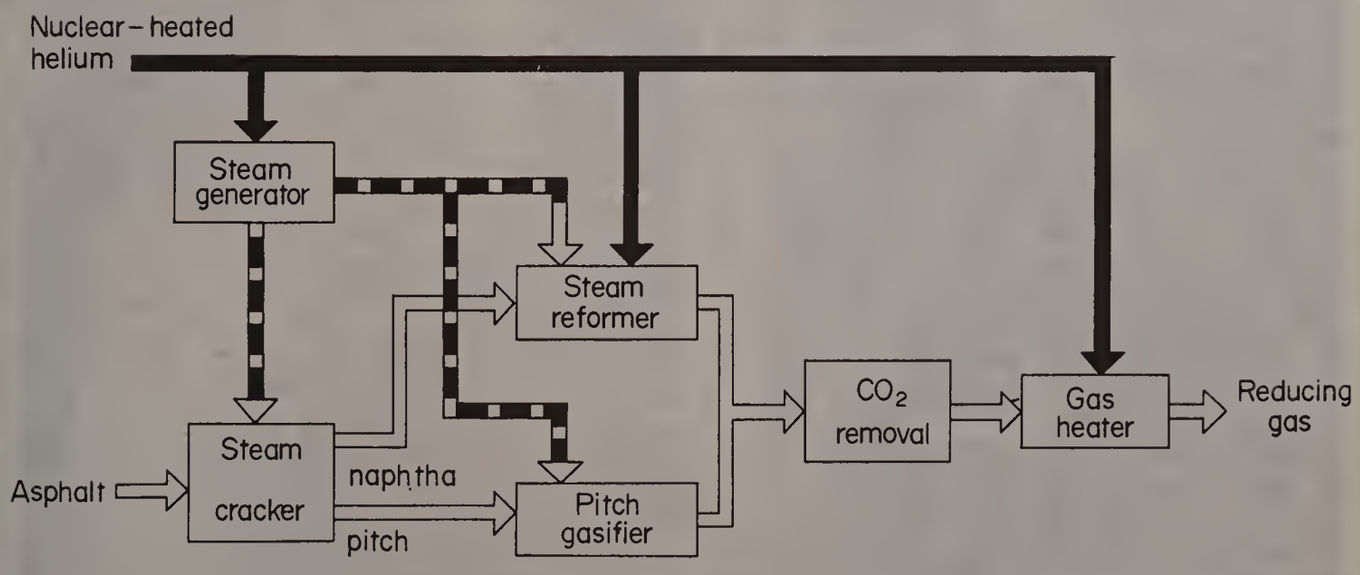
Many hydrocarbon raw materials used by industry are not converted into chemical products, but are used to provide energy or maintain suitable conditions for the desired chemical transformation to take place. A striking example is the production of iron and steel. High-grade anthracite coal used to make coke, a material essential for the operation of blast furnaces, accounts for about 10% of all energy resources used in Japan. Yet, virtually none of the carbon content of coke appears in the steel product; the coke provides heat and a chemical reductant (carbon monoxide) for reduction of iron oxide.

Coal is still available in abundant quantities, but high-grade coal suitable for making coke will likely be in short supply within a few decades. The blast furnace may well be on the way to technological extinction.

As a substitute, the steel industry will need a system which will not compete for scarce, high-grade hydrocarbon resources. The answer appears to be a hydrid chemical-nuclear system, with nuclear reactors providing energy for upgrading low-grade hydrocarbons. The reductant for steelmaking will be "reducing gas", a mixture of hydrogen and carbon monoxide at about 850°C. When passed over iron oxide (ore pellets) in a shaft furnace, iron is produced.

One low-grade carbon source likely to be upgraded to reducing gas is asphalt, the byproduct of petroleum refining often used as a road paving material. Asphalt's hydrocarbon content has been virtually ignored for its potential chemical value. It is a tarry material, and no feasible way of upgrading asphalt had formerly been available, or even seriously considered. This is no longer true. Japan, the USA and the Federal Republic of Germany are investigating high-temperature gas-cooled reactors as an energy source for upgrading hydrocarbons and promoting chemical reactions. An experimental reactor in Japan is expected to be operating in 1985-1990, and a pilot plant for nuclear steelmaking is expected to begin operation in the early 1990's.

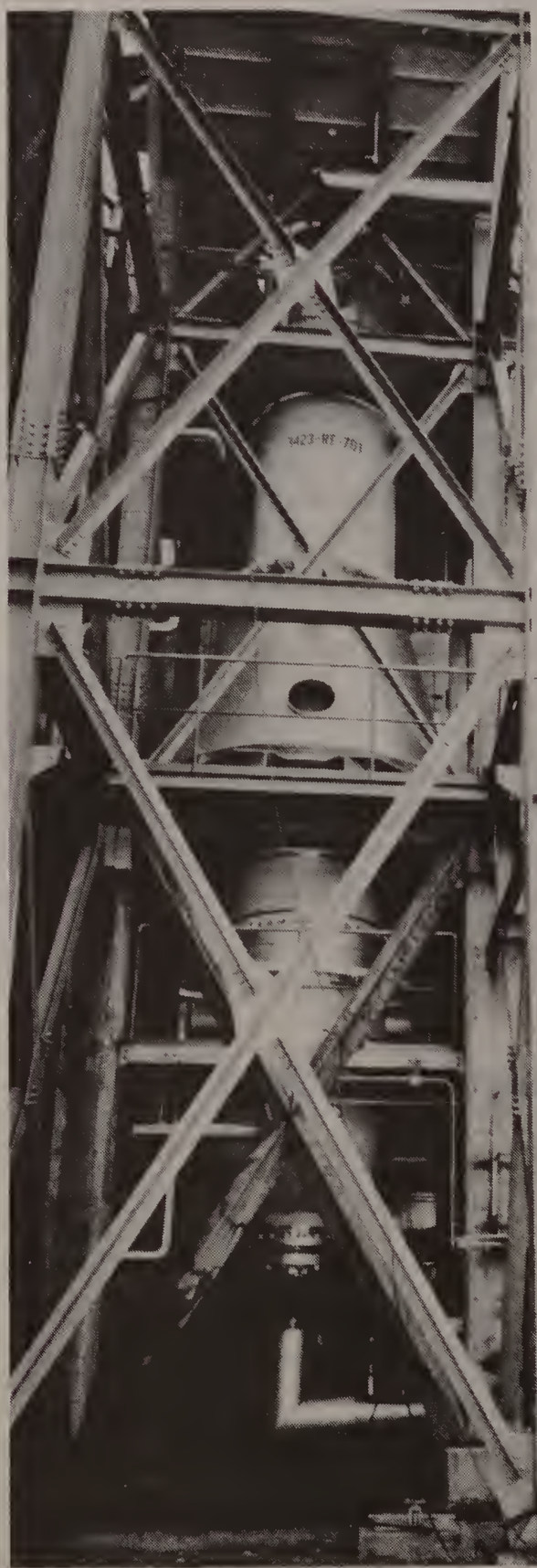
Present research aims in several seemingly discordant directions, but ultimately, all phases

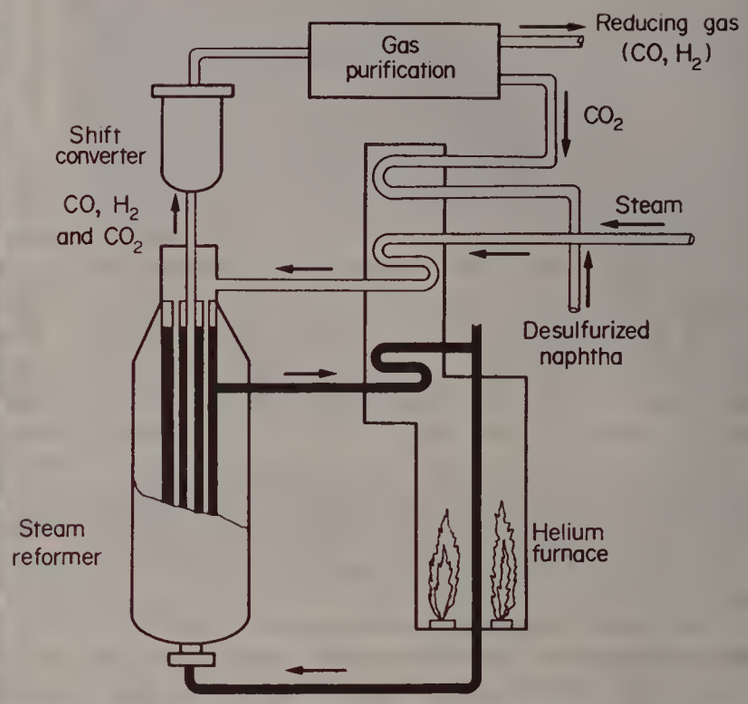


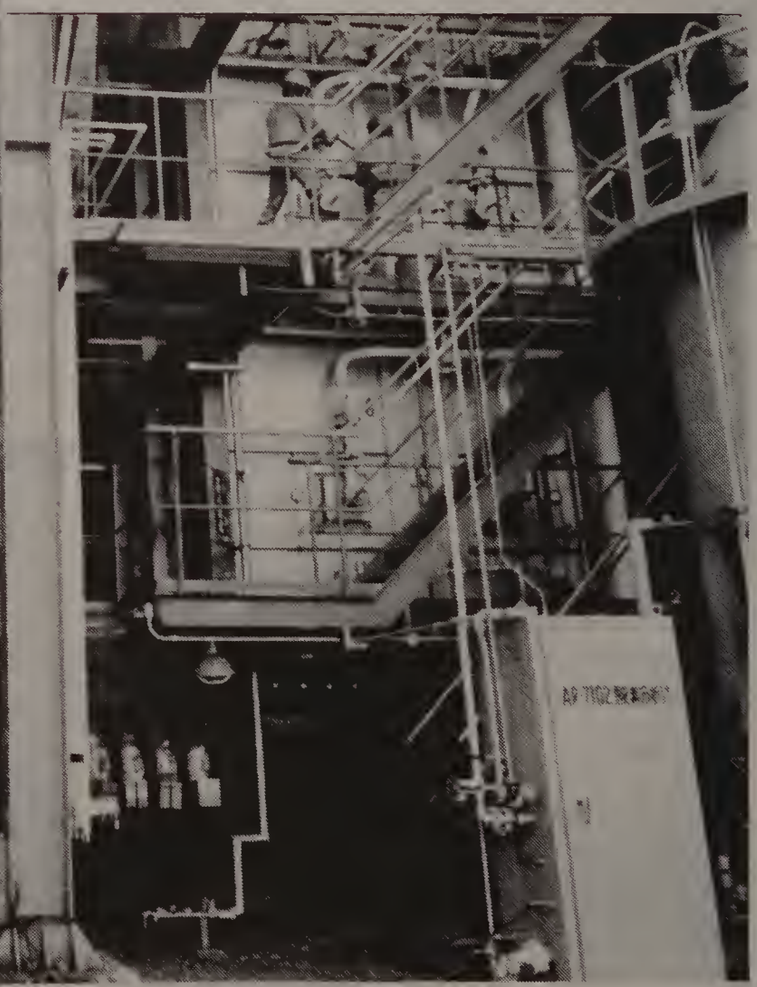
A nuclear reactor will provide energy for upgrading asphalt to reducing gas, to be used for metallurgical reduction of iron oxide. An initial steam cracking of asphalt yields mainly light hydrocarbons (naphtha) and pitch. Conversion of these products to reducing gas is being carried out in two experimental pilot-plants in Japan.

of the project will converge to provide essential technology for a nuclear steelmaking system. Fifteen Japanese companies are involved in the Engineering Research Association of Nuclear Steelmaking (ERANS), which has been funded by the Agency of Industrial Science and Technology since 1973. At the final step towards a nuclear power plant, a 50 Megawatt experimental reactor of the Japan Nuclear Power Research Institute will be linked with a reducing gas plant and a commercial shaft furnace.

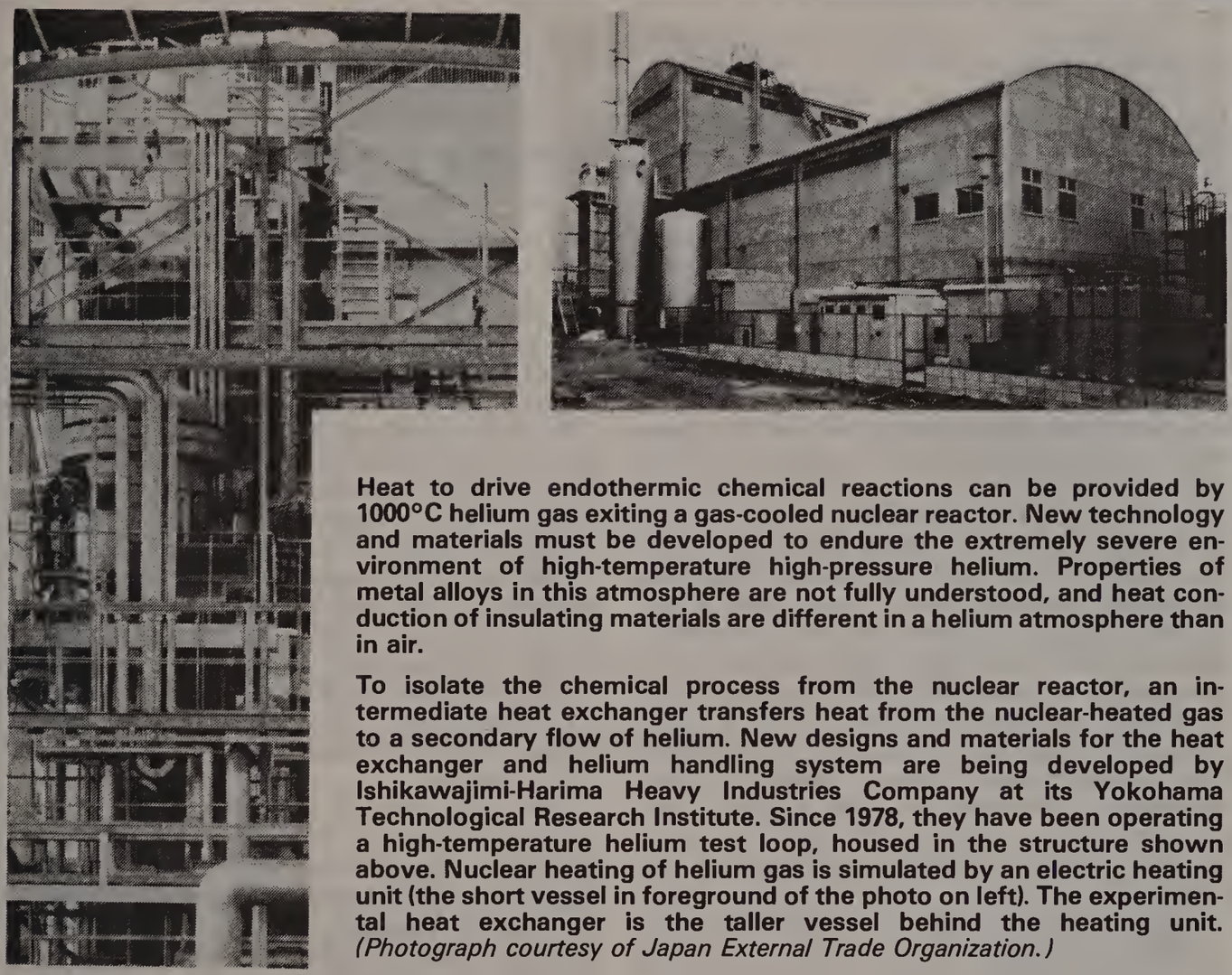
Upgrading of asphalt requires that it first be cracked with high-temperature steam. This pro-







Reducing gas for making iron is produced by this experimental pilot-plant in Yokohama, Japan. Upgraded by the plant are 100 kg/hr of light hydrocarbons made from asphalt. The hydrocarbon feed is reacted with steam inside the reformer vessel (on left of photograph). Energy for the process is provided by circulating 900°C helium. Eventually, a nuclear reactor will heat the helium, but for present experiments, a conventional furnace (on right) is used *(Photograph courtesy of Japan External Trade Organization.)*



Heat to drive endothermic chemical reactions can be provided by 1000°C helium gas exiting a gas-cooled nuclear reactor. New technology and materials must be developed to endure the extremely severe environment of high-temperature high-pressure helium. Properties of metal alloys in this atmosphere are not fully understood, and heat conduction of insulating materials are different in a helium atmosphere than in air.

To isolate the chemical process from the nuclear reactor, an intermediate heat exchanger transfers heat from the nuclear-heated gas to a secondary flow of helium. New designs and materials for the heat exchanger and helium handling system are being developed by Ishikawajimi-Harima Heavy Industries Company at its Yokohama Technological Research Institute. Since 1978, they have been operating a high-temperature helium test loop, housed in the structure shown above. Nuclear heating of helium gas is simulated by an electric heating unit (the short vessel in foreground of the photo on left). The experimental heat exchanger is the taller vessel behind the heating unit. *(Photograph courtesy of Japan External Trade Organization.)*

cess, whose energy will eventually be supplied by nuclear heat produces three products: light hydrocarbons (naphtha), pitch and fuel oil.

Light hydrocarbons are converted to reducing gas in a steam reformer. A mixture of naphtha and steam react on a catalyst surface inside the reformer vessel. Hot circulating helium gas supplies energy for the reaction. During steam reforming, oxygen is transferred from water molecules to the hydrocarbons. The products are hydrogen, carbon monoxide and carbon dioxide gases. Additional hydrogen may be produced by shifting the equilibrium reaction of carbon monoxide with steam with a suitable catalyst in a "shift converter". Subsequent removal of carbon dioxide yields a gas with a high content of hydrogen.

A pilot plant to study the production of reducing gas from naphtha has been in operation since May 1978. The experimental plant, built in Yokohama (Japan) by Chiyoda Chemical Engineering & Construction Company, can convert 100 Kg/hr of light hydrocarbons into reducing gas. Central to the operation of the plant is the steam reformer. Heat for the reaction is provided by circulation of high-temperature helium. For present research work, a conventional furnace heats the helium gas to 900°C, but ultimately, nuclear heat will be used.

Another experimental plant has also been built by the same company to investigate the production of reducing gas from pitch, a second hydrocarbon product made from asphalt. It uses thermal cracking with 900°C steam, but first, the pitch is converted to solid particles in a fluidized-bed reactor. A second fluidized-bed reactor gasifies the particles into a hydrogen-rich mixture. The test plant can convert 200 kg/hr of pitch into reducing gas, and has been providing operating data since September 1978.

The drive towards nuclear steelmaking has been most vigorously pursued in Japan, a country with an intensive concentration on steelmaking and a dependence on imported hydrocarbon resources. Yet, other industrialized nations are involved with developing chemo-nuclear reactor systems. Research projects aimed at high-temperature gas-cooled nuclear reactors are underway in the USA and Federal Republic of Germany. In 1977, the governments of these two countries signed an agreement for mutual cooperation in this field of research, later to be joined by France and Switzerland. The German experimental high-temperature gas-cooled reactor has attained a temperature of 950°C, while an American prototype has maintained operating temperature above 700°C. Further progress will depend upon the development of high-temperature alloys and heat exchanger designs. Technological developments allowing nuclear heat to be utilized in steelmaking will likely clear the way for applications in other chemical industries.

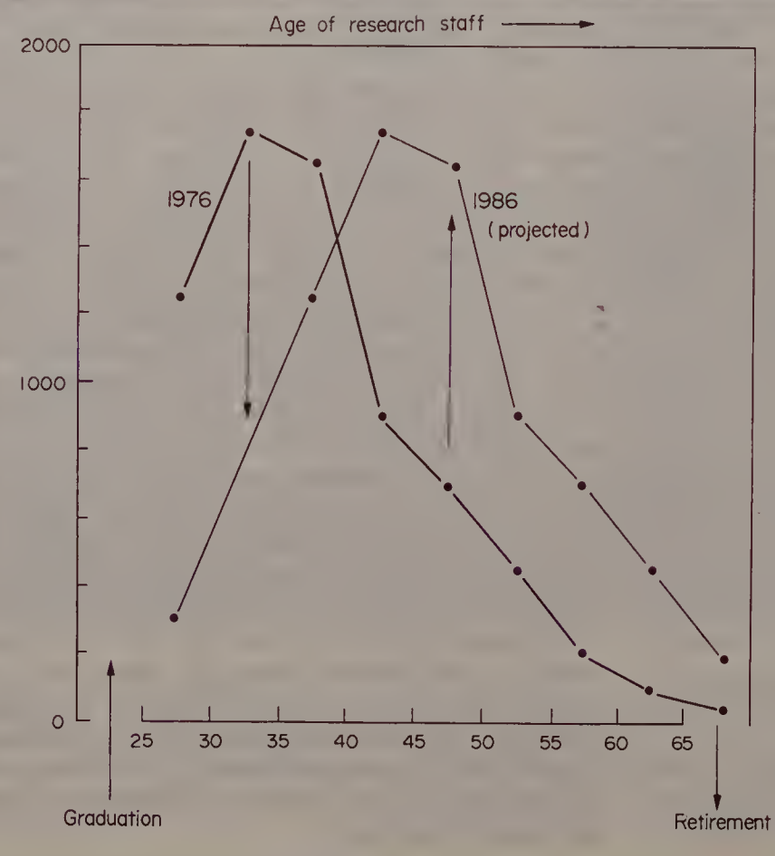
The door closes for new faculty posts but the jolt is not yet felt

Young chemists face dismal prospects for obtaining permanent university appointments, and disturbing consequences will arise for those who have secured university posts. A warning of impending consequences to follow this international trend is emphatically stated by the 1978 report of the European Science Foundation, published late last year. Among European countries, the report notes, the creation of additional university posts stopped completely three or four years ago when expansion of universities and research institutes was halted by general economic recession. To fill the few openings which do arise, universities generally hire temporary staff to avoid long-term commitments. The result has been a rise in the average age of university faculties, a trend which is almost certain to continue and accelerate.

Comparing the trend in different European countries, the report states, "The similarity of the results is striking. They lead first of all to the conclusion that probably the majority of those now in employment will stay in office until the beginning of the 1990's when they will reach their normal retirement age. The demand for replacements during the next fifteen years will be exceedingly low."

Exceedingly low indeed. The chance for a junior research assistant to reach a permanent university position has plummeted from about 70% in the 1960's to about 15% in the present decade. This bleak outlook is adversely influencing the development of younger scientists heading for teaching or research careers. "Many of them", the report continues, "are choosing a professional career outside research, hesitating to undergo the risk of obtaining one of the very few openings. Others are trying to retain their positions in the research system, even if they are modest ones, because a change to another university or research institution might lessen their chance of obtaining a permanent position."

The same caution has discouraged researchers from accepting fellowships abroad. Many feel that their small chances of obtaining a permanent position are eroded even further by leaving the country to acquire working experience elsewhere. In this way, a negative selection process operates on the young scientists competing for the few available posts. "The mobility of researchers," notes the report, "which all of us have felt to be instrumental in international and especially in European scientific cooperation, seems to be seriously endangered".



The age distribution of research staff at Centre National de la Recherche Scientifique (in France) is typical of that in most European research institutes and universities. Shown here is the age distribution in 1976 (heavy line) and what it very likely will be in 1986 (light line). Very limited opportunities for aspiring researchers to enter universities and research institutes will cause a significant reduction in the number of researchers below 40 years old, and accrual of older staff members.

The effects are not limited to the young chemical researcher, but will also affect established university staff. Due to steadily increasing average age of staff in universities and research institutes throughout Europe, the proportion of research budgets (which have remained nearly constant) paid for salaries is growing steadily. Funds allocated for purchasing material and equipment is already shrinking. In the past, universities and research institutes have generally alloted about 35% of their budget for maintenance, administration, libraries and research. Expenditures for research are now being squeezed by swelling of salaries and wages.

The sweeping consequences of this situation have been recognized in a number of countries, and some steps are being taken to counter the problem. Most of these actions, however, provide short-term assistance only. "Heisenberg Fellowships" in the Federal Republic of Germany, cited as an example in the report, are limited to five years—a period during which existing difficulties will not be solved.

Training of polymer chemists is tied to trends in the plastics industry

Developments in polymer chemistry are likely to steer on a very different course than in the past, with important consequences for the content, extent and distribution of polymer chemistry education programs. Young polymer chemists graduating today can expect to face an entirely different situation than did their predecessors who developed polymer science into an important branch of chemistry during the last few decades.

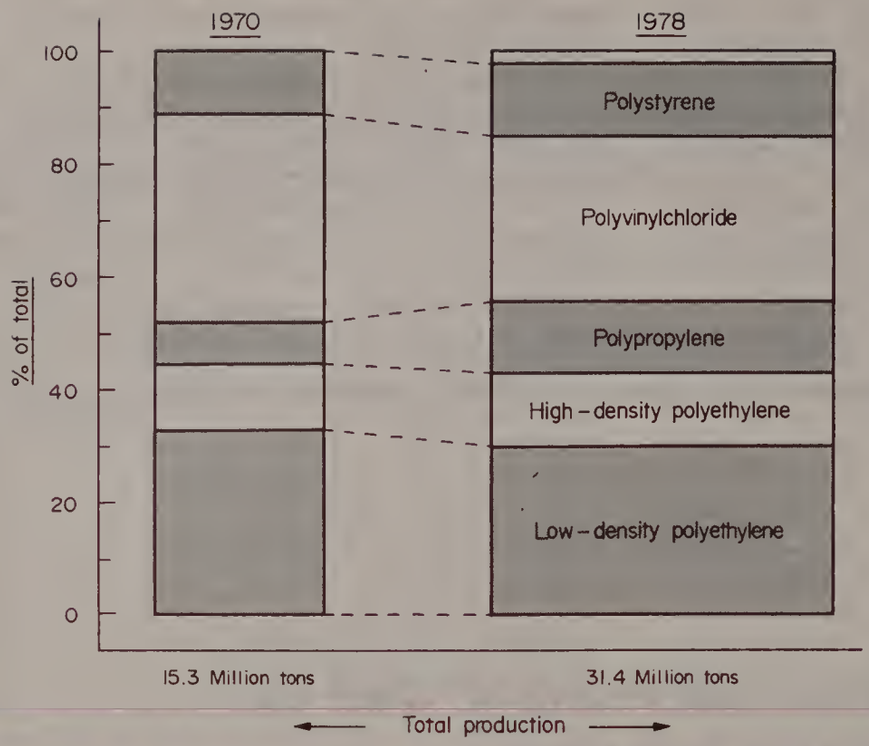
Although a plastics industry has existed for over one hundred years, it was just over forty years ago that the concept of the linear macromolecule was accepted by the scientific world. Indeed, polymer science is one of the most recent chemical subjects to emerge as an academic discipline. A few formal study courses on plastics were organized as early as the 1930's (such as the one at the Technical University of Bucharest), but the real growth was in the decade following the second World War. Only then appeared significant numbers of research papers, patents, new specialized journals and good textbooks. To provide trained people for the expanding industry, education programs in polymer chemistry were developed at many universities.

The pace of development in polymer chemistry, and polymer chemistry education, varied widely in different nations. At first, research work in the United States dominated polymer chemistry journals, but soon papers began to be published by researchers from Japan, USSR, Federal Republic of Germany, France and other Western European countries. This trend paralleled employment prospects and growth of plastics production. World capacity for polymer production has continued to increase in the last ten years, but the intensity of polymer research has eased, except in the USSR and some Eastern European countries. Many developing nations are now beginning to develop an interest in polymer production.

Growth in plastics production appears unlikely to meet previous expectations, as this would greatly increase consumption of petroleum and natural gas used for raw materials. Global production of plastics had previously been projected to increase seven-fold by the year 2000 from the present 50 million tons. Alternative raw materials such as coal (already converted to liquid hydrocarbons in South Africa), wood and sugar could be utilized—and technology for converting these into plastics is available—but this would still be more costly than using conventional sources of hydrocarbons.

The distribution of plastics production is likely to alter in the years ahead. It is expected that the USA, Japan and the Federal Germany Republic will continue to lead, with France, Italy, UK and other industrialized nations following. But, it is likely that a more prominant role will be played by Spain, Brazil, Bolivia, Mexico, Iraq, Saudi Arabia, Algeria and Nigeria.

Most plastics produced in the furture will probably be the same types as are widely used now, although demand for light-weight engineering materials and new specialty polymers will create a need for continued research. One consequence of these changes is that demand for materials scientists and engineers will probably increase, while fewer plastics chemists will be needed. Much research traditionally carried out in industrial laboratories will move to university research centers.



Global production of plastic materials doubled between 1970 and 1978, but growth among individual types of plastics varied considerably. For example, although global production of Polyvinyl Chloride (PVC) rose from 5.6 to 9.0 million tons during this period, its share of all plastics production has actually fallen. New techniques have extended the range of properties attainable with each type of plastic, so that one plastic may often be substituted for another, with prices being the most important criteria. *(Diagram adapted from "Raw Material—Polymer Interrelations—Today's Choice —Tomorrow's Option", to be published in the February issue of Pure & Applied Chemistry)*

In addition to adapting undergraduate and graduate education to changing conditions in the world polymer industries, there may be greater emphasis on post-graduate education. This includes large international conferences such as the IUPAC Macromolecular meetings, national meetings, and symposia organized by universities and professional societies. Training courses, lasting from several days to months, are conducted through UNIDO (United Nations Industrial Development Organization) and UNESCO (United Nations Educational, Scientific and Cultural Organization). Short working courses are also conducted by well-equipped individual groups in Germany, UK, USA and USSR. In countries where local courses are not given, polymer chemists can generally attend international meetings. Traveling expenses are probably the only major deterent against doing so; English is a common second language in most countries and is frequently the basic language for such courses.

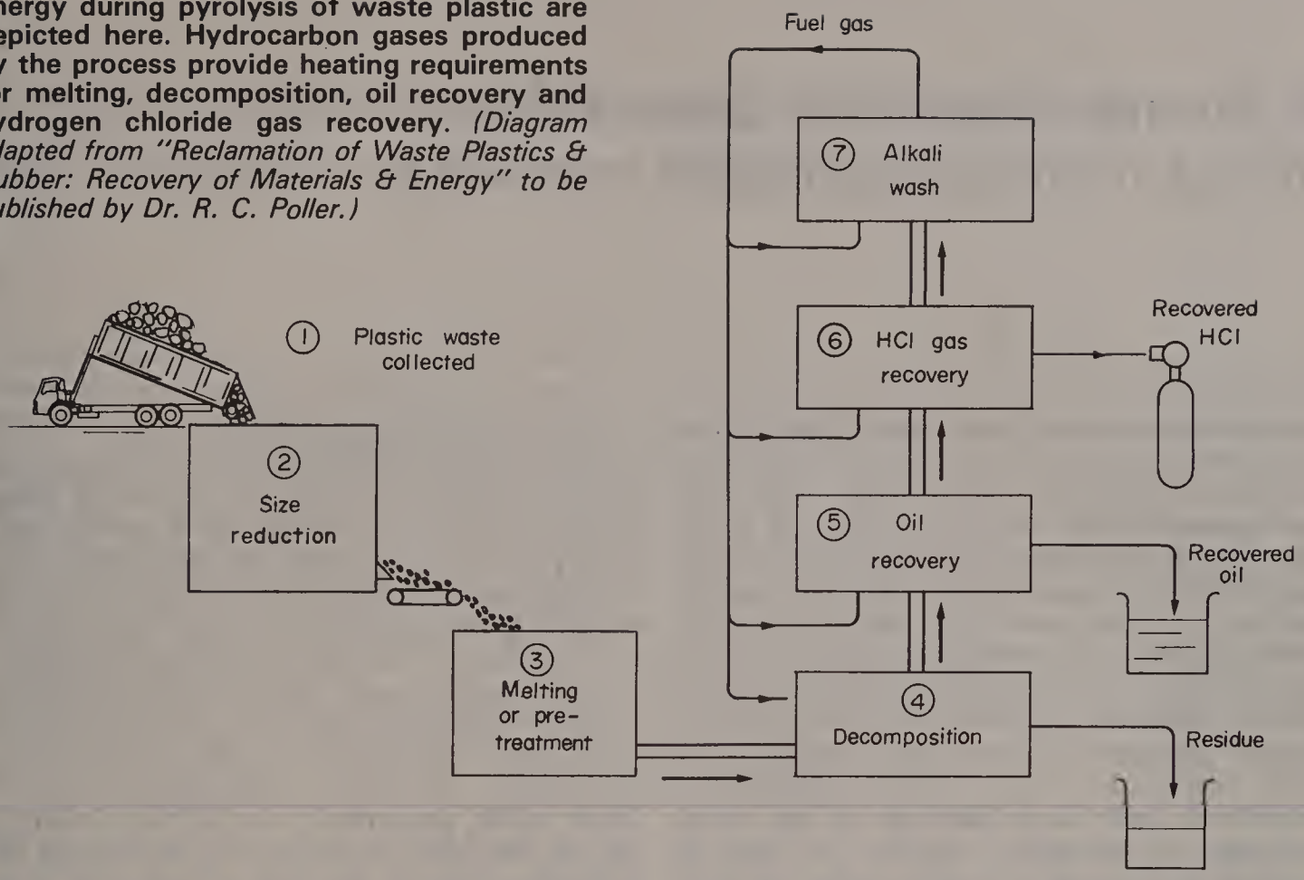
How will anticipated changes in the polymer industries affect chemical education programs throughout the world? And, how do present polymer education programms differ in their approach? These questions have been the focus of much discussion within the IUPAC Macromolecular Division Committee for the last three years. An attempt to answer them is made by a report, *Education and Training in Polymer Science and Technology,* prepared by Dr. R. P. Sheldon of the University of Bradford in the UK. The report considers undergraduate and graduate training in polymer science in Africa, Asia, the Americas, Australasia, and Europe. It will shortly be submitted for publication in polymer chemistry journals. A copy of the report may be obtained from the secretary of the Macromolecular Division Committee, Dr. A. J. De Vries, at the Centre de Recherches d'Aubervilliers, Rhone Poulenc Industries, 12 Rue des Gardinous, F-93308 Aubervilliers Cedex, France.

Recovery of polymer waste could feed the plastics industry

As production of plastics becomes more dependent on price and availability of hydrocarbon raw materials, an increasing effort is likely to be directed at recovering and reusing waste plastic. Nearly all plastic products end up eventually as household or industrial waste, although plastics are used in an unusually high proportion of disposable products. It is estimated that one-third of plastic products are discarded within one year of manufacture. The content of plastics in household waste varies widely, but in industrialized countries, is generally in the range 2-5%. It amounts to 33-82 kg/year for each person.

There has already been some progress towards practical methods for the separation

Main steps in the recovery of materials and energy during pyrolysis of waste plastic are depicted here. Hydrocarbon gases produced by the process provide heating requirements for melting, decomposition, oil recovery and hydrogen chloride gas recovery. *(Diagram adapted from "Reclamation of Waste Plastics & Rubber: Recovery of Materials & Energy" to be published by Dr. R. C. Poller.)*



and reuse of plastics. Most unmixed thermoplastic scrap is now regenerated at the factory or by independent processors, sometimes after a simple purification step of washing or melt filtration. The main problems arise with mixed plastics, or plastics mixed with other wastes.

Progress is being made in this area, as was reported by Mr. L. G. Lindfors (of the Institutet for Vatten-och Luftvardsforskning in Stockholm, Sweden) to the IUPAC Commission on Reclamation of Solid Wastes. In his paper, Mr. Lindfors noted that most polymers are incompatible with each other, making it difficult to reprocess mixtures of different plastics. There are, however, several ways now being studied to improve the physical properties of plastic mixtures. Perhaps the most obvious is to separate different plastics in the mixture, using such methods as electrostatic separation, classification by density in a jet of air, or selective solution. Many pilot plant processes are being tested, but few have yet been adapted for commercial use. A second approach is to improve adhesion between polymer phases in the blend by utilizing an additive. A final possibility is to improve the mixture properties by introducing a nonplastic component.

Rather than being incorporated directly into a new plastic mixture, waste plastic can be degraded into simpler compounds. This can be done chemically or microbiologically.

Recycling based on chemical transformations are aimed at the recovery of either energy or materials. Energy can be recovered by simple combustion (the calorific value of polyethylene is the same as that of fuel oil) or by pyrolysis. The latter involves high temperature treatment in the absence of air, the process being fueled by the gaseous products. Liquid fuels are also produced, representing a net energy gain. Material recovery is by depolymerisation to give re-useable monomers. The procedure is widely practised with polyurethane and is applicable in principle to many other polymers.

Possible products from microbial degradation are biomass compost, simple organic compounds, or new plastics with certain side groups removed from the main polymer chain. Successful experimental processes for microbial degradation of synthetic polymers began to emerge in 1978. Organisms have now been identified that are capable of degrading polyurethane polyester, polyethylene, polyethyleneglycol, polystyrene, polyvinyl alcohol, polyacrylonitrile and nylon.

The considerable problems that yet remain with microbial degradation were described to the Commission by Prof. S. J. Pirt of Queen Elizabeth College in London, UK. He pointed out that bacterial attack is limited to polymer molecules below a molecular weight limit. In some cases, only short polymer chains of a few monomer units were susceptible. Furthermore, the insolubility of polymers is a major barrier to microbial attack.

In the long-term however, degradation processes should be capable of much improvement by accelerated evolution of microbial agents in continuous cultures. It might ultimately prove possible to achieve much more control over the degree of degradation, and attain a practical method for recycling plastics into fresh hydrocarbon starting materials.

A Mobile Chemistry Laboratory brings chemistry to rural students

Chemistry teachers in rural schools face a common problem: they do not have access to modern equipment, while the need for sophisticated instrumentation becomes more apparent. Often, rural schools are too small to justify the purchase of even basic equipment. One way to overcome this problem is being demonstrated by an unusual programme carried out by the University of Poona in India. Their chemistry department developed a Mobile Chemistry Laboratory to take equipment, chemicals, charts, models, and movie projectors and films (dubbed in the local language) to secondary schools. As well as catering to the needs of rural students, the programme provides a forum for high school chemistry teachers to visit Poona University, perform experiments of interest to them, and discuss their problems.

Since the programme began nearly five years ago, the Mobile Chemistry Laboratory has visited more than 50 High Schools in rural regions of the Indian state of Maharashtra. Some of the equipment has been provided by the British Council through the British Open University system. The equipment, materials, chemicals and instructions for each experiment are assembled into kits and packed into compact, multi-functional boxes. All experiment boxes have the same outside dimensions and are colour-coded to aid packing in a van.

Two or three teachers (or senior research students) escort the van to the school being visited. They discuss with the local teachers theory of the experiments and interpretation of results, but there is also considerable interest in extending the equipment to other experiments, and substituting cheaper or simpler materials.

Experiments used in Poona University's Mobile Chemistry Laboratory are described in an article appearing in the *International Newsletter on Chemical Education,* No. 11 (Sept. 1979), prepared by the IUPAC Committee on Teaching of Chemistry, Additional information beyond that may be obtained from Prof. H. J. Arnikar and Dr. B. A. Kulkari at the Department of Chemistry in Poona University, in Ganeshkind, Poona, India.

Are the benefits of such a programme limited to small high schools with very restricted budgets? Perhaps not. The increasing sophistication and specialization of chemical instrumentation has—in some cases—virtually excluded their purchase for classroom use, even by well-supported institutions. Nonetheless, it may prove possible to share equipment among schools so that a maximum number of students can learn from relatively few pieces of sophisticated, and expensive, instrumentation.

Chemistry experiments are contained in kits, which are taken to high schools in Indian villages. Each kit contains equipment and chemicals for one experiment. Some of the kits shown here demonstrate fractional distillation and extraction, preparation of acid-base indicators from flowers and fruits, and variations in the rate of ethyl acetate hydrolysis and hydrogen peroxide decomposition. *(Photograph courtesy of Poona University.)*

Common interests of the chemical industry will be explored by new IUPAC group

Greater participation of industry in international activities will be encouraged by the formation of a new IUPAC group, the Committee on Chemistry & Industry (COCI). It will form a permanent link between IUPAC and the 169 companies which have joined IUPAC's Company Associate Scheme. First introduced in 1973 to improve collaboration between industry and the Union, the Company Associates comprise a group which is unique among the 18 international scientific unions.

The new committee was first conceived to extend the informal role performed by representatives of National Company Associate Groups. Immediate goals of the new committee will be to consider IUPAC projects from the viewpoint of the chemical industry, identify those activities relating to industrial needs, and seek areas of industrial activity where there is a need for standard procedures and terminology.

Meeting at an IUPAC General Assembly for the first time last September, the committee considered subjects likely to be of mutual interest to industry and to IUPAC. These included: applications of computer technology in chemistry, catalysis, enzyme applications, chemical aspects of corrosion and bioengineering.

The Committee on Chemistry & Industry is also concerned with the public image of the chemical industry. They feel that the industry must present chemical matters to the public in a more positive manner than in the past. One proposal suggested by the committee was to include an "open day" at IUPAC-sponsored symposia dealing with general subjects of concern to the public. An exemplary illustration cited by the committee was the first CHEMRAWN conference, which dealt with Future Sources of Organic Raw Materials. In future, the committee hopes to work closely with those individuals planning other CHEMRAWN events.

One of the first tangible products to emerge from COCI's efforts is the initial issue of a newsletter. It contains background information about the formation of the committee, the organizational structure of IUPAC, membership of the committee, and a report of the committee's inaugural meeting in February 1979. The newsletter will be compiled on an irregular basis by the committee's secretary, Dr. G. Jäger. Information, comments and suggestions relating to the committee's work can be sent to his address at Bayer AG, D-5090 Leverkusen-Bayerwerk in the Federal Republic of Germany.

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Atmospheric chemistry of the planet Venus

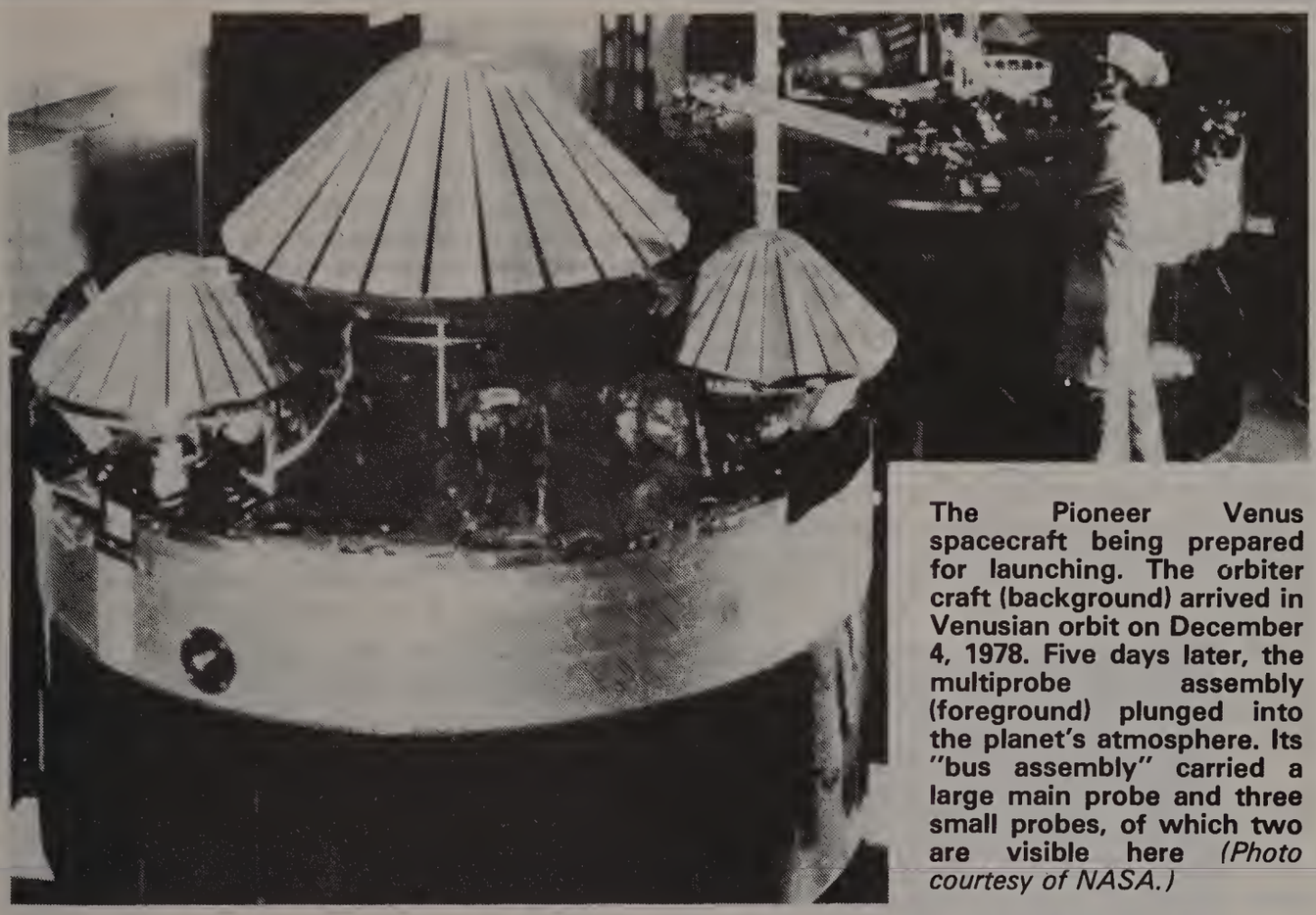
Venus is the closest planet to Earth, yet its cloud-covered lower atmosphere and surface have remained complete mysteries until very recent times. The year 1978 saw the most intensive exploration of Venus by spacecraft in history. In this single year, four American "Pioneer Venus" probes and two Soviet "Venera" probes entered the Venusian atmosphere and sampled gases below the clouds with a wide variety of instruments. The picture of Venus emerging from this probe data is significantly more complicated than that envisioned prior to these space missions. The spacecraft data discloses unexpected noble gas composition and surprising distributions of oxidized and reduced sulfur compounds. Fundamental facts have been uncovered, but additional probe missions will be required to further unravel its chemical mysteries. The need for new and innovative chemical instrumentation for such missions may provide an arena in which many other nations can become actively involved in future planetary exploration.

by Prof. Ronald Prinn
Massachusetts Institute of Technology

Venus is similar to Earth in some respects and surprisingly different in others. The planet has a very similar mass (0.81 Earth masses), radius (0.95 Earth radii), mean density (95% of Earth), and gravity (90% of Earth). Its surface temperature is a searing 750°K, but this is not a direct result of Venus' closer proximity to the sun than the Earth. Overall, the net solar energy input into the Venusian atmosphere is slightly *less* than Earth due to its higher reflectivity to solar radiation. The high surface temperature is a results of an extraordinary "greenhouse" effect resulting from the large opacity of its atmosphere and clouds to infrared radiation.

From Earth-based observations, particularly over the last 15 years, we have learned that the planet is always totally cloud-covered, and that upper parts of the clouds are composed of droplets of concentrated sulfuric acid, about 2 microns in diameter and 85% H_2SO_4 by weight. The clouds circulate around the planet once every four days. Spectroscopic observation through telescopes have revealed that the atmosphere above the clouds is predominantly carbon dioxide with minor amounts of CO (100 ppm), water vapor (10 ppm, but variable), HCl (1 ppm), HF (0.01 ppm), and SO_2 (0.1 ppm).

Prior to 1978, seven Soviet space probes were sent into the atmosphere (Veneras 4-10) and three American spacecraft passed by the planet (Mariners 2,5 and 10). These early missions indicated very high surface temperatures and pressures (about 90 times the normal Earth atmospheric pressure). They also verified that carbon dioxide was the predominant constitutent of the atmospehere. The Venera probes reported that the clouds enshrouding the planet extend down only to an altitude of about 50 km. Below the clouds, small amounts of water vapor were detected. Tracking of the Venera probes through the atmosphere showed that wind velocity within the clouds was over 350 km/hr, incredibly fast by Earth standards, although the atmosphere was nearly motionless near the surface. The fast easterly wind accounted for the 4-day circulation of the visible



The Pioneer Venus spacecraft being prepared for launching. The orbiter craft (background) arrived in Venusian orbit on December 4, 1978. Five days later, the multiprobe assembly (foreground) plunged into the planet's atmosphere. Its "bus assembly" carried a large main probe and three small probes, of which two are visible here *(Photo courtesy of NASA.)*

clouds. Underneath, the planet spins on its own axis extremely slowly, only once every 244 days.

Understanding the chemistry of the Venusian atmosphere focussed on four outstanding questions: Why is the atmosphere predominantly carbon dioxide when solar radiation continually decomposes CO_2? What causes sulfuric acid to be formed, and create the cloud layer above 50 km altitude? Why is Venus so deficient in water (containing in its atmosphere thousands of times less water than the Earth's oceans)? And, why does the atmosphere contain so much more HCl, HF and sulfur compounds than the atmosphere of the Earth?

Answers to the first two questions follow from the cycle of chemical reactions occurring in the Venusian atmosphere. Of special interest is the role of COS (carbon-oxysulfide) in the chemical cycle. Curiously, the conversion of COS to sulfuric acid first proposed to explain atmospheric chemistry on Venus has subsequently been found applicable to Earth! COS has been discovered in our own atmosphere, and studies show that it may be the dominant sources of H_2SO_4 in the Earth's stratospheric sulfuric acid layer. This layer is presently very thin, but large increases in the release of COS could translate into a widening of the sulfuric acid layer. Major sources from which COS originates on Earth, and breakdown mechanisms which destroy COS, have not been clearly identified. However, it is conceivable that coal gasification and other fuel conversion processes could become an important COS source. The consequences of increased COS generation needs to be considered, and Venus clearly provides an extreme example of what a planet shrouded in sulfuric acid clouds would be like.

The role of Cl, ClO, ClOO and HCl in the atmospheric chemistry of Venus were also considered before their important bearing on the Earth's ozone layer was realized. This is perhaps not surprising, since HCl concentrations on Venus are about 1000 times greater than those in the Earth's ozone layer.

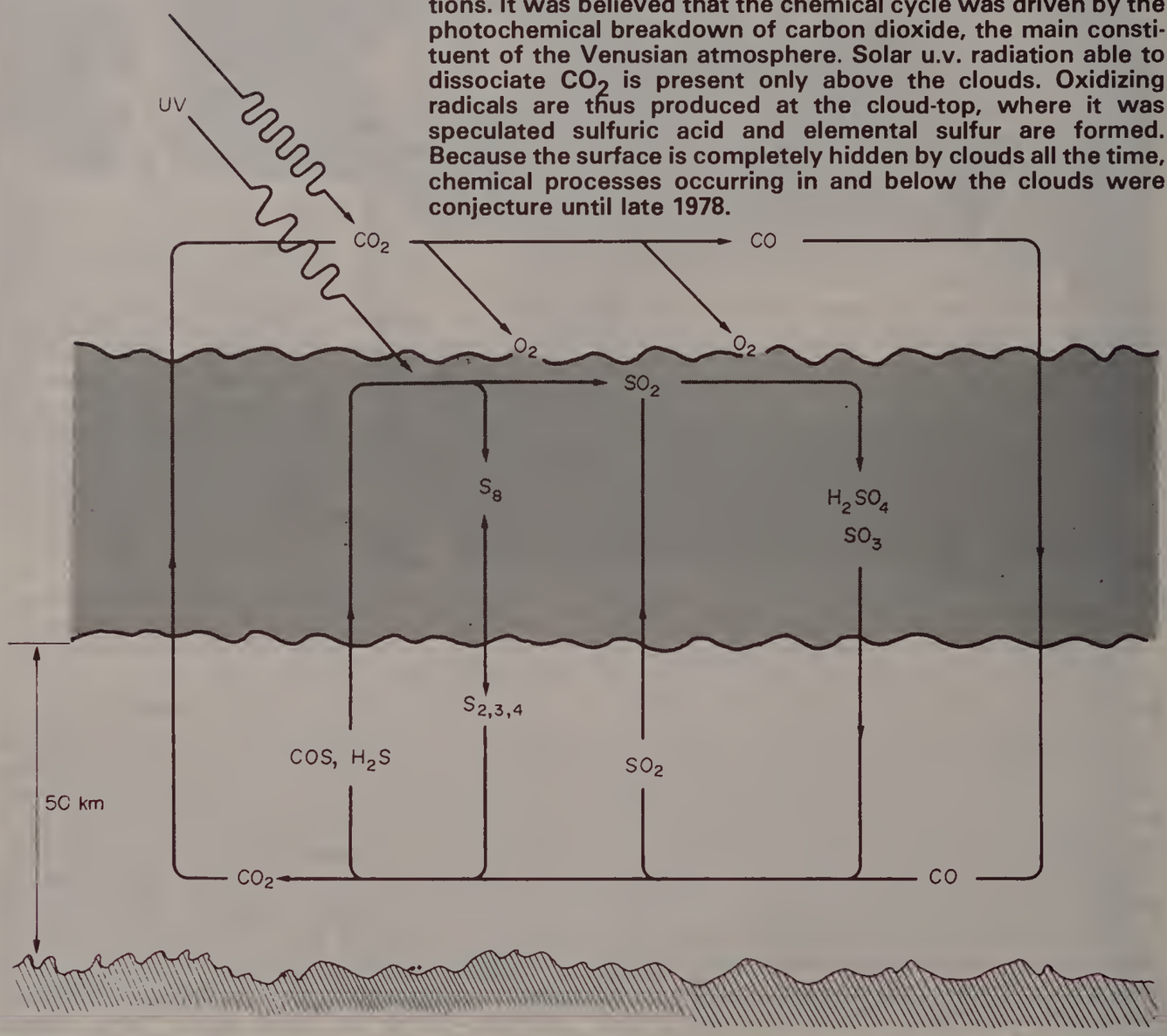
Even before the most recent spacecraft experiments, sufficient information was known to outline basic features of the cycle of chemical reactions occurring in the Venusian atmosphere. The cycle can be considered to start at very high altitudes—above the cloud layer. There, carbon dioxide (the most abundant compound on the atmosphere) would be continuously dissociated by u.v. radiation of the incident sunlight. The CO_2 molecules would fragment into CO and oxygen atoms. As these products diffuse downwards, oxygen atoms form molecular oxygen. Some of the reaction products are recycled back to CO_2, but a significant flow of CO and O_2 (about 10^{12} molecules/cm^2/s) survive the passage down to the cloud-top level.

At the top of the cloud layer, oxygen combines with photodissociation products of HCl to produce strong oxidizing radicals (OH, HO_2 and C10).

According to the proposed (pre-1978) model of Venusian atmospheric chemistry, these oxidizing radicals encounter SO_2, COS and H_2S diffusing upwards from the lower atmosphere. Sulfur dioxide is rapidly oxidized to SO_3, which then forms sulfuric acid. At the same time, COS and H_2S absorb far-ultraviolet solar radiation, causing the molecules to fragment and produce S atoms and SH radicals. These react to form more SO_2 , for example by the two step reaction:

The accepted view of Venus Before 1978

Early spaceflight missions flying past Venus indicated that its atmosphere undergoes a continuous cycle of chemical reactions. It was believed that the chemical cycle was driven by the photochemical breakdown of carbon dioxide, the main constituent of the Venusian atmosphere. Solar u.v. radiation able to dissociate CO_2 is present only above the clouds. Oxidizing radicals are thus produced at the cloud-top, where it was speculated sulfuric acid and elemental sulfur are formed. Because the surface is completely hidden by clouds all the time, chemical processes occurring in and below the clouds were conjecture until late 1978.



$$S + O_2 \qquad SO + O,$$
$$SO + OH \qquad SO_2 + H.$$

Once again, SO_2 is oxidized, and ultimately yields sulfuric acid. If insufficient oxygen is present for these reactions to produce SO_2, an alternative reaction produces elemental sulfur:

$$S + COS \qquad S_2 + CO.$$

The supply of oxygen determines the relative amounts of sulfuric acid and elemental sulfur produced. Sulfur, rather than sulfuric acid, is produced in O_2-deficient regions. Variation in oxygen supply reaching the cloud layer thus provides an explanation for the remarkable spatial patterns observed in the ultraviolet absorption of the cloud layer.

Sulfuric acid droplets migrate through the cloud layer. Upon reaching the cloud base at a height of 50 km, the sulfuric acid evaporates to SO_3 and H_2SO_4 vapor. These vapors encounter warmer and warmer temperatures as they diffuse downwards. Near the surface, sulfur oxides undergo a series of thermochemical reactions. An important reactant is the carbon monoxide produced at high altitude by photodissociation of CO_2. It acts as a chemical reductant which converts SO_3 back to COS, SO_2 and H_2S. The chemical cycle is then completed.

This cycle was able to account for the persistence of carbon dioxide in the atmosphere, despite continuous dissociation of CO_2 molecules by ultraviolet radiation. Also, it explained how sulfuric acid, the major component of the cloud layer, was produced.

This, then, was the accepted view of the Venusian atmosphere *before* 1978, when two American spacecraft and the Russian Venera 11 and 12 missions arrived at the planet. The two Pioneer spacecraft were launched independently: one began orbiting Venus on December 4th, and on December 9th, a multiprobe craft arrived at Venus carrying a large "main" probe and three smaller probes in a "bus" assembly. All four probes departed the bus independently, and entered the Venusian atmosphere

at different times. Veneras 11 and 12 approached Venus later the same month, and both entered the atmosphere near the equator. What new things have these missions told us about atmospheric chemistry on Venus?

The most striking information derived from the 1978 spaceprobe data concerns the distribution of COS. That data, obtained by the Venus Pioneer mass spectrometer, indicates that COS concentrations decrease very abruptly above 20 km altitude—plummeting from about 1000 ppm to less than 3 ppm at 24 km. In view of the turbulent mixing of the atmosphere, it is difficult to imagine a destructive mechanism of sufficient potency to account for the dramatic disappearance of COS above 20 km (one undramatic possibility is that some COS was producted inside the mass spectrometer itself, and this possibility is presently being explored by investigators).

Not as spectacular—but possibly very significant—is the relative steady decrease of H_2S concentration with height, from about 1000 ppm near the surface to less thant 30 ppm at 24 km altitude. Another important clue is the probable detection of gaseous elemental sulfur in the lower atmosphere. The presence of S_2, S_3 and S_4 is implicated by strong light absorption at wavelenths below 600 nm observed at low altitudes by a spectrophotometer aboard a Venera probe. The presence of elemental sulfur is confirmed by the mass spectrometer on the Pioneer probe (although some of the S, S_2 and S_3 detected may have resulted from decomposition of COS and polyatomic sulfur in the ionization chamber of the mass spectrometer). The sudden disappearance of COS above 20 km, and the detection of H_2S, S, S_2 and S_3 below 22 km argues strongly for a chemical environment that is highly reducing within 20 km of the surface. It indicates that conversion between oxidized and reduced sulfur compounds is much more complicated than envisaged before the 1978 spaceprobe data. It implies that the transition from oxidized sulfur compounds to reduced sulfur compounds, previously thought to occur just below the cloud base at about 45 km altitude, takes place at much lower altitude. Apparently, other processes, not previously considered, play a key role in driving the chemical cycle. In addition, the detection of molecular oxygen (about 70 ppm) at 24 km altitude points to a low altitude source of O_2 which far exceeds the amount formed by CO_2 photodissocation above the clouds.

One intriguing explanation is that near-u.v. and visible radiation penetrate through the clouds and bring about photochemical reactions in the lower atmosphere. For example, the sulfanes H_2S_2, H_2S_3 and H_2S_4 have very weak S-S bonds which are ruptured when the compounds absorb near u.v. and visible light. If these are present in the lower atmosphere (as yet, there is no definitive evidence that they are), photochemical reactions could be initiated by their photochemical breakdown.

Another possible initiator for photochemical reactions is gaseous sulfur chains, such as S_3 and S_4. Their presence in the lower atmosphere is indicated by both light absorption and mass spectroscopic evidence. Very little is know about the structure and photochemistry of S_3 and S_4, but at a first approximation, we can assume that they begin to dissociate at about the same radiation wavelengths as the analogous sulfanes H_2S_3 and H_2S_4 (namely, 570 and 840 nm). In laboratory studies, S_3 exhibits very strong absorption bands in the near u.v. spectrum, while S_4 absorbs radiation throughout the blue-green spectrum. Photons of absorbed radiation have more than enough energy to dissociate S_3 and S_4 molecules.

Photodissociation of sulfanes and polyatomic sulfur would likely yield highly reactive SH radicals and excited sulfur atoms. Reaction of excited sulfur atoms could account for the destruction of COS and H_2S, and provide a plausible mechanism for the disappearance of these compounds at about 20 km altitude. The reaction of S or SH with water would also serve as a source of oxygen in the lower atmosphere, as O_2 and SO_2 would be ultimate reaction products.

The 1978 spacecraft data leaves intact the belief that sulfuric acid droplets—the main component of the clouds—is produced at the cloud-top level by oxidation of SO_2. But the lack of COS and H_2S inside the clouds, and the apparent presence of oxygen, would likely rule out formation of elemental sulfur inside the cloud layer. It seems likely that elemental sulfur is formed below the cloud layer.

These conclusions are consistent with data provided by an instrument aboard the Pioneer main probe designed to measure the size of cloud particles. It indicated that the size of cloud particles were unevenly distributed, with many clustered around diameters of about 7, 2.7 and less than 0.8 microns. The medium-diameter particles are believed to be concentrated sulfuric acid droplets formed near the top of the cloud layer, at 70 km height. The large diameter particles are attributed to dilute sulfuric acid near the bottom of the cloud layer. The smallest particles are apparently condensation nucleii, perhaps elemental sulfur or other involatile material. However, this interpretation is not completely certain. Measurements made by the cloud particle spectrometer, mass spectrometers and gas chromatographs leave some question about the relative amounts of sulfur present as elemental sulfur particles, SO_2, COS and H_2S.

While some definitive conclusions can be drawn from the spacecraft data, in other respects, it is puzzling and contradictory. For example, argon concentrations in the atmosphre measured by mass spectrometry were significantly greater than measured by gas chromatography on *both* the American and Soviet missions. However, mass spectrometers onboard Pioneer and Venera probes reported the same *relative* abundances of the two isotopes Argon-36 and Argon-40. This result is most significant because it provides a valuable clue in determining the origin of the solar system.

The isotope ^{36}Ar is probably a remnant from the primitive solar nebula, the massive spinning gas and dust disc which was the precursor of our solar system. It is the predominant argon isotope present

in the sun. On the other hand, ^{40}Ar was largely formed *after* the formation of the planets in our solar system. It is released by radioactive decay of ^{40}K contained in rocks of the planet's crust. The Pioneer and Venera missions in late 1978 (and earlier missions to Mars) tell us that the abundance of the ^{36}Ar "nebular remnant" decreases very rapidly from Venus, to Earth, to Mars. The venus probes found that ^{36}Ar was present with about equal abundance as ^{40}Ar, while on Earth, the amount of ^{36}Ar is only 1/300th the amount of ^{40}Ar.

Wide variation in the proportion of the ^{36}Ar remnant of the primeval solar system implies that mineral grains from which the planets formed contained different amounts of remnant gases. The content of gases such as argon decreased rapidly with distance from the primitive sun. Perhaps this was due to decreasing pressure and different mineral composition in the outermost part of the primeval solar nebula.

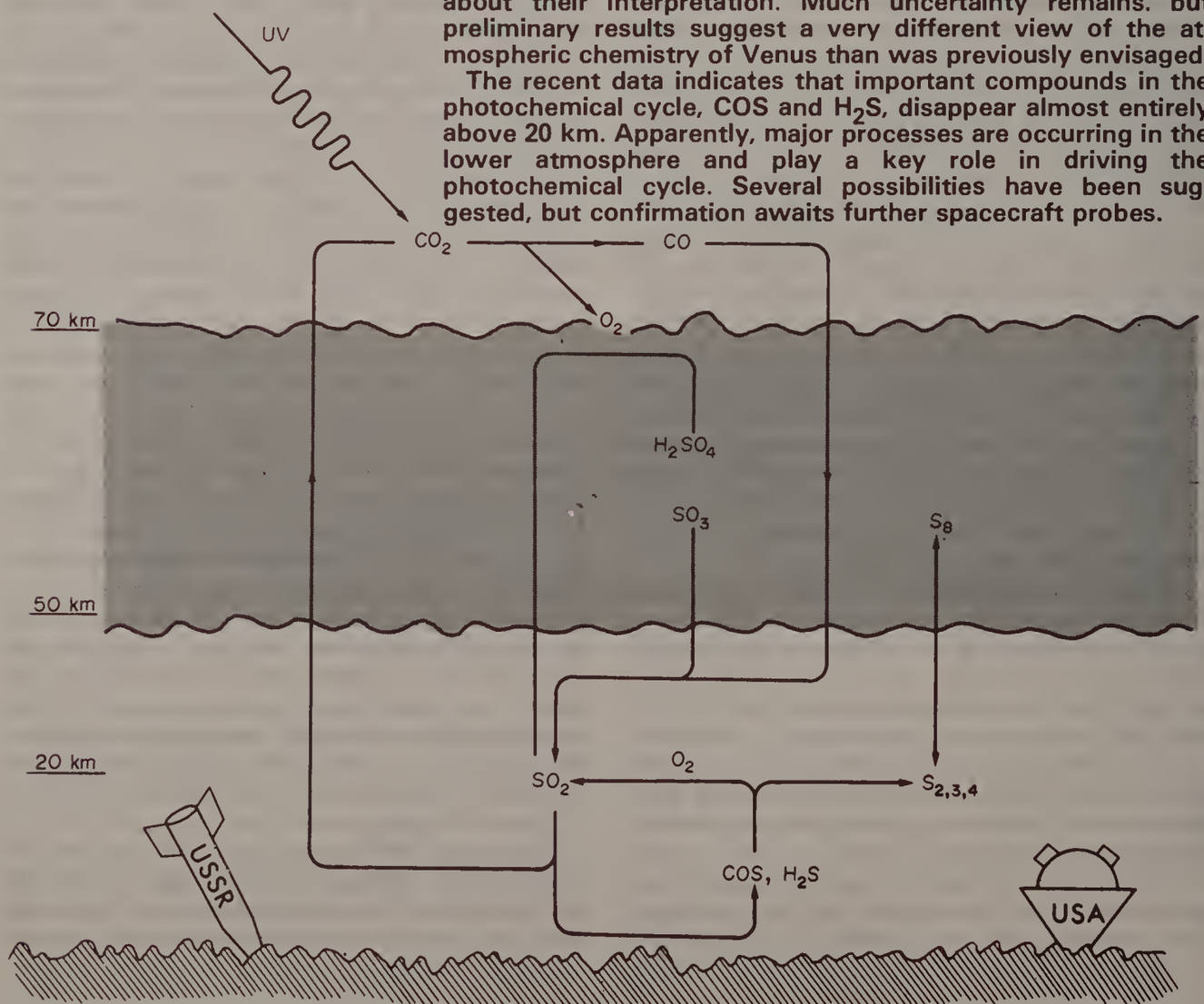
How can we explain the lack of water on Venus? Two competing hypotheses have been advanced. The first considers the lack of water to be a consequence of conditions under which Venus and Earth formed. Dust particles in the primitive solar nebula would have contained water in the form of hydrous minerals, which are stable only at lower temperatures (less than 500° and 350°K respectively for the minerals tremolite and serpentine). Current theories about the formation of Venus suggest that it was formed at temperatures too high to have received a complement of hydrous minerals nearly as large at that of Earth.

The competing hypothesis argues that Venus began with about the same amount of water as did Earth. However, higher surface temperatures caused water to be driven into the atmosphere, rather than contained in oceans. In the primeval atmosphere, u.v. radiation would have rapidly dissociated water molecules to hydrogen and oxygen. The hydrogen would likely have escaped into outer space, while oxygen would have been retained as carbon dioxide, or

A new outlook on atmospheric chemistry After 1978

In 1978, six spaceprobes plummeted beneath the clouds of Venus, sampled the atmosphere, and transmitted data back to Earth. Scientists are still poring over the results and argueing about their interpretation. Much uncertainty remains. but preliminary results suggest a very different view of the atmospheric chemistry of Venus than was previously envisaged.

The recent data indicates that important compounds in the photochemical cycle, COS and H_2S, disappear almost entirely above 20 km. Apparently, major processes are occurring in the lower atmosphere and play a key role in driving the photochemical cycle. Several possibilities have been suggested, but confirmation awaits further spacecraft probes.



incorporated into ferric minerals on the surface. The atmosphere would thus have reached its present depletion of water. Both hypotheses have their strong adherents.

How can we account for the presence of HCl, HF and sulfur compounds at concentrations far exceeing those in the atmosphere of Earth? These gases are thought to result from thermochemical equilibrium between very hot surface minerals and the atmosphere. At surface temperatures found on Venus, for example, minerals containing calcium fluoride, silica and magnesium silicate react with water vapor to produce HF gas. Surface rocks containing iron sulfide can react with atmospheric carbon dioxide to yield COS.

What is the next step in the exploration of Venus? NASA presently plans a Venus Orbital Imaging Radar (VOIR) experiment, which will be launched using the Space Shuttle in late 1984, arriving at Venus in May 1985. The primary purpose of the mission will be to obtain a detailed high-resolution map of the Venusian surface using advanced radar techniques. Of course, the cloud cover on Venus has precluded visual observation of surface features. Radar examination of the planet's surface would be a tremendous boon towards understanding geological processes occuring on Venus, and might provide insight into the elemental and mineralogical composition of the surface.

Future missions will also likely include additional spectroscopic experiments to resolve contradictions arising from the Pioneer and Venera data. For these missions, spectroscopic and electronic equipment must be developed that is capable of surviving reasonable periods of time on the hot Venusian surface. Free-floating balloons might provide an ideal platform for measurements of chemical composition of the atmosphere.

As the space programs in the USA and USSR mature, advantages could be gained by increased cooperation—not only between these two countries with major launching capabilities, but also between these and other nations. For example, smaller countries unable to fund their own space research program might develop analytical instrumentation for inclusion in future American or Russian space missions. Reliable low-volume instruments will be needed for *in situ* gas, cloud and surface composition measurements. There is the recurring suspicion, at least in this author's mind, that some remarkable space instrumentation would result if a greater number of analytical chemists became interested in this challenge.

Further information

For descriptions of all results from the Pioneer Venus mission, see *Science,* 203(1979)pp.743-808, and *Science,* 204(1979)pp.31-121. For details on atmospheric chemistry, see R.G. Prinn, *Geophysical Research Letters,* 5(1978)pp.973-976, and *Geophysical Research Letters,* 6(1979).

About the author:
Ronald Prinn is presently Associate Professor of Meteorology at the Massachusetts Institute of Technology (in Cambridge, Mass. USA). He served on NASA advisory groups for exploration of the inner and outer solar system. Prof. Prinn is presently a member of the "Committee on Planetary and Lunar Exploration" (of the US National Academy of Sciences) and the "International Commission on Planetary Atmospheres and their Evolution" (of the Int'l. Union of Geodesy and Geophysics). Although in the meteorology department at MIT, Prof. Prinn received much of his formal training in chemistry. He received his B.Sc. degree in chemistry and mathematics, and an honors masters degree in chemistry from the University of Auckland, New Zealand. His Sc.D. degree in chemistry was granted from the Massachusetts Institute of Technology.

IUPAC views its future course at General Assembly Meeting

The changing role of IUPAC, and changing needs of the international chemical community, were reflected in the meetings and discussions at the IUPAC General Assembly, held in Davos (Switzerland) from 2-10 September.

IUPAC's CHEMRAWN program (Chemical Research Applied to World Needs) continues to gain momentum, and encompass new areas where there is a high priority need of global interest where chemistry is a dominant theme. Following the first highly-successful CHEMRAWN conference (held in Toronto in July 1978) dealing with "Future Sources of Organic Raw Materials", the next step will be a major international meeting dealing with agriculture. CHEMRAWN II will be entitled "Chemical Research to Meet the World's Expanding Food Needs". The conference, to be held February 7-11, 1982 in the Phillipines, is being organized with the help of Dr. Normal Borlaug (the only Nobel laureate in the field of agriculture), Dr. W. David Hopper (Vice-president of the World Bank), Dr. Nyle C. Brady (Director-General of the Int'l Rice Research Institute), and Dr. Charles Dennison (Executive-Director of the US Council on Science and Technology for Development).

Other areas for which CHEMRAWN activities were considered include: a second conference on "Future Sources of Organic Raw Materials" in 1983-85, an international meeting on the "Chemistry of the Oceans", and a conference on "Chemical Aspects of Water Quality and Conservation" (particularly as it applies to arid regions of the Earth).

A need for reductions in expenditures in 1981 are discussed at the council meeting (above) at the conclusion of the General Assembly. Addressing representatives of IUPAC's 42 national member organizations are the treasurer Prof. O. Horn and finance committee chairman Prof. A. Björkman (at right of main table on platform). Also present are incoming president Zollinger, secretary-general Ourisson, retiring president Smets, and ex-president Cairns.

Prof. Zollinger (right), ". . qualititative improvements are possible, even if there is no quantitative growth".

The CHEMRAWN committee is also cooperating with IUPAC's Clinical Chemistry Section to consider a joint CHEMRAWN conference on the "Chemical Basis of Carcinogenesis, Mutagenesis and Teratogenesis". Within the last few years, clinical chemistry has been undergoing rapid development, and clinical chemists have undertaken a much more active role within IUPAC. The expanding contribution of the Clinical Chemistry Section was acknowledged by granting equal status with IUPAC's six other Divisions (Physical, Inorganic, Organic, Macromolecular, Analytical and Applied Chemistry Divisions).

Progress at the General Assembly was not limited to technical matters; there was an unprecedented diplomatic development. An agreement was reached whereby chemists from both Chinese chemical societies (located in Taipei, Republic of Taiwan and in Beijing, People's Republic of China) will be represented in IUPAC and participate in its ac-

The agreement whereby two Chinese Chemical Societies will be member organizations of IUPAC was a major diplomatic breakthrough. At the conclusion of the General Assembly, Dr. Wang Chi Wu (one of the representatives for the Chinese Chemical Society in Taipai, Taiwan) expressed his appreciation and approval. He noted to the IUPAC council that ". . scientists in the Republic of China on Taiwan have been benefitiaries of international scientific interactions . . We certainly wish that our compatriots on the other side of the Taiwan Strait enjoy and exploit the opportunities we have had".

Here, the agreement is signed by representatives of the Chinese Chemical Society in Taiwan, Dr. Wang Chi Wu (second from right), Dr. Paul L. C. Hao (left) and Prof. Fa-Ching Chen (right). A central role in the sensitive negotiations was performed by president Smets (sitting, second from left), secretary-general Ourisson (standing, left) and incoming president Zollinger (standing, right).

Representatives of the Chinese Chemical Society in Beijing sign the agreement that will allow their member chemists to participate in IUPAC activities for the first time. Signing the agreement are Prof. Hu Yadong (left) and Prof. Lu Jiaxi (center), as Profs. Smets, Zollinger and Ourisson watch.

tivities. The agreement, which is similar to one adopted recently by the Int'l Union of Biochemistry, shows that cooperation within science can precede, and possibly set the stage for, cooperation in the political forum.

The successful negotiation and signing of the agreement attracted considerable coverage in the public news media. Through the efforts of (incoming) President Zollinger to inform European newspaper editors, several articles were published about the event. One, published in the September 14th issues of *Neue Zurcher Zeitung,* was written by Prof. Zollinger. It reported that (translation) . . . "for the first time in history, both Chinese nations have representatives in one of 18 scientific governing bodies comprising the international Council of Scientific Unions (ICSU); a step which, until now, one or other of these nations was not prepared to take."

"At its General Assembly in 1979, ICSU decided that each scientific governing body should abide by the principle of the universality of science and not exclude any scientific organization representing that particular branch of science in a *Geographically-defined* territory."

"IUPAC, the largest of these international governing bodies . . . has been considering the Chinese question for some time as, until now, only Taiwan was a member. Preliminary discussions between the President (Prof. Smets) and Vice-President (Prof. Zollinger) of IUPAC at the IUPAC Congress in Helsinki in August 1979, led to proposals for the solution to this problem . . ."

"According to the Statutes of IUPAC, when there is cause for doubt, the President of IUPAC has the power to issue a decree to settle the matter. Thus, for nations where circumstances do not allow chemists to participate in international functions, the concept 'country' is so defined that it refers to a *geographical* and not a political territory."

"Both Chinese delegations for their part conceded that their countries would appear in the list of member countries as 'China' and not according to their official names. Similarly, the two organizations representing the two territories would be known as 'The Chinese Chemical Society' and 'The Chemical Society located in Taipei, China'."

"Similar discussion took place at the end of July in Toronto with the International Union of Biochemistry (IUB). They were also successful, but, according to the Statutes of IUB, agreements of this sort become effective only after a period of 4 months, i.e. in November 1979. IUPAC and IUB worked together closely to achieve this agreement. IUPAC is indebted to IUB for the continuous flow of information concerning the progress of their discussions."

Of course, most of the meetings at the IUPAC General Assembly did not deal with spectacular diplomatic breakthroughs, but with the 400 or so projects dealing with nomenclature, technical reports and sponsorship of conferences. Most are a continuation of existing projects, but several new developments were evident.

A new "Commission on Solubility Data" was created within the Analytical Chemistry Division. It will coordinate the enormous Solubility Data Project—a task begun by an ambitious subcommittee. Over the next ten years, 80-100 volumes will be published, comprising by far the most complete collection and evaluation of solubility data ever attempted.

The newly-elected IUPAC vice-president, Prof. S. Nagakura of the University of Tokyo. He will succeed Prof. Zollinger as president of the next General Assembly in 1981.

Other Commissions are also embarking on new projects, or aiming in new directions. In some cases, this is reflected by new names for existing Commissions. Topics relating to heterogenous catalysis will now be investigated by the renamed "Commission on Colloid and Surface Chemistry *including catalysis*". Variations in atomic abundances will be given greater emphasis by the newly-renamed "Commission on Atomic Weights and Isotopic Abundances". The former "Commission on Fermentation" is expanding its scope to consider all aspects of Biotechnology.

Two Commissions dealing with Food Properties and Food Contaminants were formally merged into a new "Commission on Food Chemistry". So too did the IUPAC Council approve the creation of a "Commission on Pesticide Chemistry" from the amalgamation of two previously-existing Commissions concerned with Terminal Pesticide Residues and Pesticide Residue Analysis. Also meeting for the first time at an IUPAC General Assembly was the new Committee on Chemistry and Industry, which had just prepared a first newsletter describing their initial activities and plans.

The council meeting marking the conclusion of the General Assembly was chaired by the retiring president Smets, who was granted an honorary doctorate two weeks later from the University of Mainz in recognition of his contribution to macromolecular chemistry. During his address to the council, he spoke about the internal organization of IUPAC, and how it affects the relations of IUPAC with other

organizations. Prof. Smets pointed out that "the existing structure of the Union is that prevailing when the Union was founded 60 years ago, and corresponds to the main classical division of chemistry. This classical subdivision results in a very rigid and formal structure which does not correspond anymore to the actual interdisciplinary character of modern science, particularly of chemistry. Undoubtedly, interdivisional activities will have to be considered increasingly in the near future, and the present framework of IUPAC is too rigid and lacks the ability to undertake quickly any new problems arising."

"It is my personal conviction that first of all, better liason and direct contacts between Officers of Section/Divisions . . . should be strongly enhanced. Only by exchange of ideas and personal interaction can the Union Officers become aware of existing problems or newly created situations."

Prof. Smets later considered another aspects of IUPAC's internal structure, the policy that all IUPAC bodies meet at the General Assembly every two years. A reduction in the frequency of the General Assembly, and reduced financial support for travel expenses, had been proposed as a measure to improve the financial outlook for IUPAC. He reported the decision of the Executive Committee to propose "a voluntary reduction of membership (of titular members, who receive the most reimbursement of travel and subsistence expenses) . . and organization of meetings in conjunction with scientific Symposia in non-General Assembly years." But, he warned, "Reduction in frequency of the Assembly could seriously affect the proper functioning of a Union as large as IUPAC, and in the long run endanger its unity."

At the conclusion of the council meeting, Prof. Heinrich Zollinger became the new IUPAC president. His term of office will extend for two years, until the end of the next General Assembly in Leuven, Belgium in late-summer 1981. Then, the newly-elected Vice-president, Prof. S. Nagakura (of Japan) will suceed him as president.

President Zollinger's address, marking the beginning of his presidency, focussed on those areas which he felt should be given priority. "Above all," he stated, "I do believe in the universality of IUPAC, and in particular I will support the spirit of the US National Committee resolution to maximize interaction between the Union (IUPAC) and *all* chemists throughout the world. I ask Dr Overberger to bring that message of the Conference to Chemical Society Presidents (15-17 September), in which Dr. Overberger will be my ambassador."

"I would like to support and develop in particular three areas of our activities: firstly, I will give very high priority to CHEMRAWN activities. I hope that the Divisions and Commissions as well as organizers of IUPAC-sponsored Symposia will make additional suggestions and active contributions to the work of our CHEMRAWN committee."

Secondly, I hope that better integration of industrial chemistry into IUPAC activities will become a fact now that COCI (the Committee on Chemistry & Industry) has been formed. All our Company Associates and potential candidates for that status have to be better informed of IUPAC activities and they are invited to make proposals for new activities or changes in existing activities."

"Thirdly, I will focus my attention on keeping the IUPAC label as a label of quality and even try to increase the qualitative value of that label. This refers to all our activities, both purely scientific matters such as giving sponsorship only to high-quality symposia, but also to matters related to technological and industrial problems as well as to our organizational structure. I know from my experience at the Swiss Federal Institute of Technology (ETH) that qualitative improvements are possible, even if there is not quantitative growth."

"I invite all National Adhering Organizations, Officers and Members of IUPAC bodies to join me in working towards these goals."

What advice would retiring President Smets pass on to the man ultimately to succeed him in office, newly-elected vice-president Nagakura (left)? Is it a few words of guidance for difficult decisions ahead, or a comment on the dinner wine? Hundreds of IUPAC delegates attended this dinner, hosted by the Swiss Chemical Society, but only Prof. Ourisson (right) knows for sure.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1980

CHEMICAL HYDRODYNAMICS

March 31-April 2. 3rd Int'l Conference on Physico-chemical Hydrodynamics. Madrid, Spain.
(Prof. Manuel G. Velarde, Facultad de Ciencias, C-3 Universidad Autonoma de Madrid, Cantoblanco, Madrid, Spain)

SOLUTE-SOLVENT INTERACTIONS

June 2-6. 5th Int'l Symposium on Solute-Solute-Solvent Interactions. Florence, Italy.
(Prof. I. Bertini, Faculta di Farmacia, Instituto di Chimica Generale e Inorganica, Università degli Studi di Firenze, Via Gino Capponi 7, I-50121 Firenze, Italy)

ZEOLITES

June 2-6. 5th Int'l Conference on Zeolites. Naples, Italy.
(Prof. R. Sersale, Instituto di Chimia Applicata, Università di Napoli, Piazzale Tecchio, I-80125 Napoli, Italy)

POLYVINYL CHLORIDE

June 3rd Int'l Symposium on Polyvinyl Chloride. Cleveland/Ohio, USA.
(Dr. E. A. Collins, Diamond Shamrock Corporation, PO Box 348, Painesville, Ohio 44077, USA)

POLYMERS

June 11-13. Int'l Symposium on the Statistical Mechanics of Phase Transitions in Polymers. Cleveland, USA.
(Prof. A. J. Hopfinger, Dept. of Macromolecular Science, Case Institute of Technology, Case Western Reserve University, Cleveland, Ohio 44106, USA)

ORGANIC SYNTHESIS

June 15-20. 3rd IUPAC Symposium on Organic Synthesis. Madison/Wisconsin, USA.
(Prof. B. M. Trost, Dept. of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, Wisconsin 53706, USA)

CATALYSIS

June 30-July 4. 7th Int'l Congress on Catalysis. Tokyo, Japan
(Prof. I. Yasumori, Dept. of Chemistry, Tokyo Institute of Technology, 2-12-1 Ookayama, Megmo-ku, Tokyo 152, Japan)

MACROCYCLIC LIGANDS

July 3-5. Symposium on Macrocyclic Ligands. Basel, Switzerland.
(Prof. T. A. Kaden, Institut für Anorganische Chemie der Universität Basel, Spitalstrasse 51, CH-4056 Basel, Switzerland)

COORDINATION CHEMISTRY

July 7-11. 21st Int'l Conference on Coordination Chemistry. Toulouse, France.
(Prof. F. Gallais, Laboratoire de Chimie de Coordination du CNRS, BP 4142, 205 Route de Narbonne, F-31030 Toulouse Cedex, France)

CARBOHYDRATE CHEMISTRY

July 7-11. 10th Int'l Symposium on Carbohydrate Chemistry. Sydney, Australia.
Prof. S. J. Angyal, School of Chemistry, University of New South Wales, PO Box 1, Kensington, New South Wales 2033, Australia)

PHOTOCHEMISTRY

July 13-19. 8th Symposium on Photochemistry. Seefeld, Austria.
(Prof. J. Schantl, Institut für Organische und Pharmazeutische Chemie, Universität Innsbruck, Innrain 52a, A-6020 Innsbruck, Austria)

ANALYTICAL CHEMISTRY

July 20-26. SAC 80: Int'l Conference on Analytical Chemistry. Lancaster, UK.
(Dr. J. D. R. Thomas, Dept. of Chemistry, UWIST, King Edward VII Avenue, Cardiff CF1 3NU, UK)

FERMENTATION

July 20-27. VI Int'l Fermentation Symposium. London/Ontario, Canada.
(Prof. J. E. Zajic, Faculty of Engineering Science, University of Western Ontario, London, Ontario, Canada N6A 5B9)

PHYSICAL ORGANIC CHEMISTRY

August 17-22. 5th IUPAC Conference on Physical Organic Chemistry. Santa Cruz/California, USA.
(Prof. J. F. Bunnett, Division of Natural Sciences - II, University of California, Santa Cruz, California 95064, USA)

MAGNETIC RESONANCE

August 25-30. Int'l Conference on Magnetic Resonance. Delft, Netherlands.
(Prof. J. Smidt, Delft University of Technology, Dept. of Applied Physics, PO Box 5046, NL-2600 GA Delft, Netherlands)

THERMODYNAMICS

August 26-29. 6th Int'l Congress on Thermodynamics. Merseburg, GDR.
(Prof. Margit Ratzsch, Technische Hochschule "Carl Schorlemmer", Leuna-Merseburg, DDR-42 Merseburg 6, Geusaer Strasse, GDR)

MEDICINAL CHEMISTRY

September 2-5. 7th Int'l Symposium on Medicinal Chemistry. Torremolinos, Spain.
(Prof. R. Madroñero, Sociedad Española de Química Terapéutica, Juan de la Cierva 3, Madrid 6, Spain)

POLYMERIZATION MECHANISMS

September 3-5. Int'l Symposium on Polymerization Mechanisms. Liverpool, UK.
(Prof. G. C. Eastmond, Donnan Laboratories, Dept. of Inorganic, Physical & Industrial Chemistry, University of Liverpool, PO Box 147, Grove Street, Liverpool L69 3BX, UK)

TOXICOLOGY OF NICKEL

September 3-5. 2nd Int'l Conference on Environmental and Occupational Toxicology of Nickel. Swansea, UK.
(Prof. F. W. Sunderman Jr., Dept. of Laboratory Medicine, University of Connecticut, PO Box G, Farmington, Connecticut 06032, USA)

MACROMOLECULES

September 7-13. Int'l Symposium on Macromolecules. Florence, Italy.
(Prof. F. Ciardello, Instituto Chimica Organica Industriale, Via Risorgimento 35, I-56100 Pisa, Italy)

CRYSTAL GROWTH

September 10-16. 6th Int'l Conference on Crystal Growth and (September 17-25) 4th Int'l Specialists School on Crystal Growth. Moscow, USSR.
(Dr. E. I. Givargizov, Institute of Crystallography, USSR Academy of Sciences, Leninskii Prosp. 59, SU-117333 Moscow, USSR)

BOC CONFERENCE - OXYGEN

September 15-18. 2nd BOC Priestley Conference (Theme: production, storage and transport of Oxygen in living systems and by industry). Birmingham, UK.
(Dr. John F. Gibson, Asst. Secretary (Scientific & Educational), The Chemical Society, Burlington House, London W1V 0BN, UK)

POLYMER NETWORKS
September 15-20. 7th Discussion Conference on Polymer Networks. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelin, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

MARINE NATURAL PRODUCTS
September 16-20. 3rd Int'l Symposium on Marine Natural Products. Brussels, Belgium.
(Dr. J. C. Braekman, Faculté des Sciences, Avenue F.-D. Roosevelt 50, Université Libre de Bruxelles, B-1050 Bruxelles, Belgium)

NATURAL PRODUCTS
September 21-27. 12th Int'l Symposium on Chemistry of Natural Products. Tenerife, Spain
(Prof. A. G. Gonzalez, Instituto de Productos Naturales, Carretera la Esperanza 2, La Laguna, Tenerife, Spain)

HETEROCYCLES
September 22-27. 21st Prague Microsymposium on Ring-Opening Polymerization of Heterocycles. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelin, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

1981

TOXICOLOGY
March 4-7. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142-144 Oxford Road, Cowley, Oxford OX4 2DZ, UK)

PARTICLE INTERACTIONS IN COLLOIDS
March 16-21. Int'l Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

CHARACTERIZATION OF POLYMERS BY NMR
July 22nd Prague Microsymposium on Characterization of Dynamic and Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlacek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovskeho n.2, CS-162 06 Praha 616, Czechoslovakia)

SURFACE AND COLLOID SCIENCE
July 5-10. 4th Int'l Conference on Surface and Colloid Science. Jerusalem, Israel
(Prof. A. Silberberg, Dept. of Polymer Chemistry, Weizmann Institute of Science, Rehovot, Israel)

MACROMOLECULAR CHEMISTRY
July 6-9. 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, Ier Étage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France)

POLYMER CHARACTERIZATION
July 13-17. Int'l Symposium on Advances in Polymer Characterization. Durham, UK
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

CAROTENOIDS
July 26-31. 6th Int'l Symposium on Carotenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, PO Box 147, Liverpool L69 3BX, UK)

ORGANOMETALLIC CHEMISTRY
August 9-14. 10th Int'l Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

NONBENZENOID AROMATIC COMPOUNDS
August 30-September 4. 4th Int'l Symposium on Chemistry of Nonbenzenoid Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Dept. of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

CHEMICAL PHYSICS
October 1-7. Int'l Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-6, SU-117334 Moscow, USSR)

1982

CHEMISTRY RELATING TO AGRICULTURE
February 7-11. Chemical Research to Meet the World's Expanding Food Needs.
(CHEMRAWN II). Manila, Phillipines.

MACROMOLECULES
July 12-16. IUPAC Macromolecular Symposium. Amherst/Mass., USA.
(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA)

IUPAC CONGRESS
August 16-22. 28th IUPAC Congress. Probable topics are: Chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, inorganic chemistry, organic chemistry, and physical chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

A complete listing of international chemistry conferences in chemistry and related topics, including those sponsored by IUPAC, will be published in the next issue of Chemistry International.

Answers to Surface Analysis Crossword Puzzle

(1) SIMS (Secondary Ion Mass Spectrometry)
(2) Ion Probe
(3) Sputter
(4) Monolayer
(5) Profile
(6) Thin Film
(7) Escape Depth
(8) Trace Element
(9) Auger

OFF THE PRESS

Recent IUPAC publications

Proceedings of 4th Int'l Symposium on Plasma Chemistry

Extended abstracts of invited lectures and full-length contributed papers presented at the 4th Int'l. Symposium on Plasma Chemistry, held 27-31 August 1979 in Zurich Switzerland, are contained in two recently-published volumes.

Volume 1 is devoted to papers presented in the *Topical Meeting on Interactions of Low Pressure Plasmas with Solid Surfaces* and in the *Round Table on Thermal Plasma Processing.* Papers presented in the main symposium are contained in volume 2.

The rapid development of this field is reflected in the large number of excellent papers. A particular emphasis is on the interactions of low pressure plasmas with solid surfaces, on plasma etching, low pressure plasma CVD, amorphous semiconductors, ozone synthesis, as well as on applications of high-temperature plasmas to materials processing.

Indices of authors, key words and compounds enable the reader to locate quickly those papers relevant to his own interests.

The 812-page proceedings may be ordered from the Institute of Inorganic Chemistry, University of Zurich, Att: PD Dr. S. Veprek, Winterthurerstrasse 190, 8057 Zurich, Switzerland. The price is 130 Swiss Francs, which includes postage for surface mailing (air mail posting should be specified if desired, and the purchaser will be billed accordingly).

THE LAST WORD

Chemical history is shaped by a maker of wine bottles

Probably no unit is more widely used in chemistry than the Litre, yet relatively little is known about the 18th century maker of wine bottles Claude Émile Jean-Baptiste Litre. He first proposed the system of specifying volumes in terms of the mass of liquid a container would hold. He was the pre-eminent manufacturer of chemical glassware of his day—the first to produce precision graduated cylinders and the inventor of the buret. His graduated cylinders varied in internal diameter by less than 0.1% of their length, and were graduated into hundreds—or even thousands—of their volume.

Unfortunately for historians, Litre did not keep a journal of his work or his personal life, and correspondence exchanged with his close friend Celsius have been lost. His fine glassware has not survived. A set of graduated cylinders donated to the Royal Society of England in 1765 were destroyed 47 years later during the preparation of nitrogen trichloride by Sir Humphrey Davy. Most details of Litre's life were inferred from the general literature of the period. This information reveals that Litre—unlike most chemists of his generation—enjoyed prosperity, good health and recognition during his lifetime. He was hard-working, but abstained from excesses, and had a placid composure.

But then, Litre was not really a chemist. He was a manufacturer of wine bottles, as was his father, grandfather, and great-grandfather. His family's wine bottles were well-known in the Bordeaux wine industry since the 1620's. No doubt, this family tradition of glass-working was a major influence when Litre began his scientific training at age 16. So too was his meeting with Anders Celsius four years later during a geological expedition to the Swedish Lapland.

Celsius served as a liason between the French expedition and Swedish officials. A professor of astronomy at the University of Uppsala, Celsius was preoccupied with precise measurement. The friendship between Litre and Celsius introduced the final element that was to prepare Litre for the most important contribution of his life.

In 1763 at age 47, Lite prepared his major written work, *Études Volumetriques.* He chose a standard volume very close to the *flacon royal,* introduced by King Henri IV in 1595 to standardize taxation of wine. However, Litre recognized that this unit was arbitrary, and suggested that volumes be specified in terms of a standard mass of liquid that a container would hold. He suggested mercury. Litre's proposal for a rationalized system of units materialized 15 years after his death, when a commission was appointed to formulate such a system, headed by the mathematician Lagrange. From this commission was born the metric system in 1795. Litre's method of specifying volume was adopted, as the standard liquid. The chemist Antoine de Fourcroy was apparently the first to suggest Litre's name for the unit of volume. Two hundred years after Litre's death, the litre was adopted as the fundamental unit of volume for the standardized international SI metric system (Systéme International).

This short sketch of the life of Claude Émile Jean-Baptiste Litre is based upon a most-interesting 3 page article written by Dr. K.A. Woolner of the University of Waterloo (Canada). It appears in the 11th issue of the *Int'l. Newsletter of Chemical Education,* published by the IUPAC Committee on Teaching of Chemistry. A copy of the news letter may be obtained free-of-charge from Mr. P.D. Gujral at the IUPAC secretariat.

Chemistry International

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INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and appplied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

NATIONAL MEMBER ORGANIZATIONS

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Asociación Química Argentina **(Argentina)**
Australian Academy of Science **(Australia)**
Verein Österreichischer Chemiker **(Austria)**
Comité National Belge de Chimie **(Belgium)**
Associação Brasileira de Química **(Brazil)**
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National Research Council of Canada **(Canada)**
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Chemistry International

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MANUSCRIPTS

Prospective authors should send an outline of the proposed article to the Editor with a brief letter explaining why the subject might be of wide interest or significance.

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When the Symposium on "New Horizons in Hydrocarbon Chemistry" was held last December at the University of Southern California, IUPAC president and dyestuff chemist Heinrich Zollinger presented the Opening Remarks. His comments were aimed at hydrocarbon chemists attending that conference, but pertain as well to all participants at IUPAC-sponsored conferences, and to all chemists concerned with how global events will steer their work. Here, in part, is what he said.

THE EDITOR'S DESK

The energy "problem" — a challenge for scientists

IUPAC sponsors some 20-30 symposia and scientific conferences each year which take place all over the world. In granting sponsorship, IUPAC insists that two major conditions are fulfilled: One is a political condition, namely that any qualified person, whatever their country of origin, is allowed to attend the conference. The second condition concerns the quality and relevance of the subject of the conference.

There is one aspect of the Symposium on New Horizons in Hydrocarbon Chemistry which differentiates it from the other 23 conferences sponsored by IUPAC in 1979. This symposium inaugurates a new university building, the Hydrocarbon Research Institute. I believe the Institute has a pioneering new task, a task which we did not forsee clearly even a few years ago.

Six years ago, in October 1973, the Arab oil producers turned off the oil tap. When it was turned on again, crude oil was four times dearer than previously. This serious situation, which led to the worst world recession since the end of the Second World War, is called today the "First Oil Crisis". Meanwhile, we are in the throes of the second crisis. This was brought about by the well known events in Iran and is characterized by a cut back in production and drastically higher prices, which will probably increase further. New crises will certainly arise—the only question is when and to what extent.

In everyday speech, constant familiarity has led to the "Energy Crisis" becoming synonomous with "Energy Problem". I myself use this expression even though I am conscious of the fact that it is an understatement. This applies particularly to our country (Prof. Zollinger is of Swiss nationality) whose energy supplies are extremely vulnerable.

The energy economy is a 'world' economy in the truest sense of the word, and Switzerland is only a small cog in the gears of energy economics, driven by forces which we have no way of influencing. Observations concerning the energy problem in Switzerland are therefore only of value if they are considered in relation to the global situation.

When at the beginning of 1979, Iranian petroleum production was suspended, it appeared that the shortages predicted for the middle Eighties and early Nineties were already upon us.

OPEC reacted promptly, and in June 1979 raised the crude oil price to over 20 dollars a barrel; to a level which, a few years ago, the industrialized countries had deemed unmanageable. They have since had to come to terms with even greater

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price increases. Today, crude oil costs 70% more than a year ago, and 700% more than in Summer 1973. Since the OPEC countries have realized that it is to their advantage to sell less oil, at higher prices, further price increases are virtually assured. Further, the problem of supply could become critical again.

If one relies on the most recent predictions of the International Energy Agency—a body set up by the OECD (Organization for Economic & Cultural Development) after the first oil crisis—everything points to a new shortage. It is predicted that in 1983 there will be a deficit in . . . energy supplies of the OECD countries of 200 million tons petroleum units, in 1990 a deficit of 500 million tons and in the year 2000 one of 1.4 thousand million tons. For comparison, the energy requirement of the OECD countries today is around 3.5 thousand million tons petroleum units, which is approximately 65% of the world's energy consumption.

Similar consideration have also been the concern of IUPAC since 1973, not only with regard to the energy and oil problems, but also the potential contributions of chemistry to the present and future problems of mankind. In 1975 IUPAC undertook a major new initiative know as CHEMRAWN, the acronym for "Chemical Research Applied to World Needs". The first CHEMRAWN conference was held in Toronto, Canada in July 1978 dealing with the problem of "Future Sources of Organic Raw Materials".

Because of the interdependent nature of world communities today, many of the problems facing us in both developed and less developed countries must be addressed in an international as well as a national context. With its international ties and broad range of scientific and engineering expertise available to it, IUPAC is in a strong position to play a leading role in such endeavours.

Today's chemical industries (providing plastics, textiles, solvents, cleaning agents, pharmaceuticals, agricultural chemicals and other essential consumer and industrial chemical products) are largely based on petroleum as a primary resource. It is sometimes hard to appreciate that just over 100 years ago, there were no synthetic chemical materials, with the exception of metals, glass and ceramics. All our materials were natural: for example, the fibres cotton, wool, linen and silk.

Then, in 1856 came the awakening of the synthetic chemical revolution when Sir William Perkin synthesized the first dye from coal tar. This coal-based chemical industry grew rapidly, but it was eventually overtaken by the parallel development of petroleum chemistry. It was, however, only in the 1920's that the first petrochemical was produced. This was isopropyl alcohol which was made from refinery off-gases by the sulfuric acid process. In 1940, 95% of the 3 million tons of organic chemicals still came from coal, and only 5% from petroleum. Within the next 38 years the overall production had increased more than 100-fold: in 1978 it was 340 million tons, of which 97% originated from petroleum.

The great importance of inorganic and organic chemical products in our lives is much underrated. It must become better known to the general public that the oil crisis is not only an energy crisis but also a crisis of chemical resources. It is therefore extremely important that substitution of petroleum as an energy source should now be studied intensively on a world-wide basis. In this field, progress in the near future is feasible, whereas substitution of petroleum as a source of chemicals is more difficult in the medium range, i.e. 10 - 30 years and also in the long range, i.e. a period of 100 years and more.

Innovative ways to command access to feedstocks and other resources of organic chemicals are therefore an absolute necessity. The new Hydrocarbon Research Institute has therefore a very important task. It can become a leader in this field; it can become a catalyst for similar activities in this country and in countries the world over; and it can become an ambassador of the philosophy expressed in the acronym of IUPAC's new activity CHEMRAWN = Chemical Research Applied to World Needs.

Recent clues suggest fresh outlook on how life began

How did life originate on Earth? According to a widely held view, solar radiation and electrical discharges in the Earth's atmosphere created the first amino acids and organic compounds. These accumulated in the oceans, forming a dilute "primordial soup", from which the first cell originated and began to feed. It grew and multiplied, and ultimately these first crude cells were to deplete their source of nutrients. Before that could happen, the cells had to develop the ability to utilize sunlight and carbon dioxide to provide their energy and nutritional needs.

This has been the accepted theory since the 1950's, when laboratory experiments first demonstrated that amino acids and hydrocarbon compounds formed when an electrical discharge was passed through a reducing mixture of gases very similar to that believed to have comprised the atmosphere of Earth. It is probably still the most widely held view, but new evidence casts some doubt as to whether this theory accounts completely for the origin of life.

Recent discoveries indicate that living cells—or at least organic compounds—were present relatively soon after the Earth formed about 4.6 billion years ago. The earliest date when living cells are known to have existed has been pushed back 400 million years by the discovery, two years ago, of fossilized cellular organisms in sediments believed to be 3.4 billion years old. In another development, a group of scientists from the USA, UK and German Federal Republic found hydrocarbon compounds when they analyzed the oldest rock deposit yet discovered on Earth, 3.8 billion year-old gneisses from Greenland. Based on the ratio of carbon-12 and carbon-13 isotopes, it appears that these compounds originated from living organisms.

This evidence suggests to Prof. Cyril Ponnamperuma, IUPAC representative to COSPAR (Committee on Space Research, of the International Council of Scientific Unions), that conditions necessary for life developed very soon after the planet was formed. In an article published in *Chemical & Engineering News* (Sept. 17th, 1979 issue, page 22), Dr. Ponnamperuma speculates that amino acids and other simple molecules necessary for life were formed in the solar nebula before the planets coalesced. To support this view, he cites the presence of amino acids found in eight carbon-containing meteorites discovered in the Antarctic during the last decade. Although these meteorites have been on Earth for about 200,000 years, they appear to have undergone virtually no contamination by Earth-borne material. Amino acids found in the meteorites were apparently not formed by living systems, as both optical isomers are present (unlike amino acids comprising protein of living cells).

Prof. Ponnamperuma points to the extensive number of simple organic compounds (some 50 molecules, molecular ions and free radicals) which have been identified in outer space by radio astronomers during the last few years. Could these compounds have collected into meteorites which fell upon Earth, and contributed to the primordial soup from which life evolved? Meteorites have apparently bombarded the Earth in great numbers during the early history of the Solar System. Even now, the Earth receives annually about 10 grams of meteorite debris per square kilometre. Small meteorites are destroyed by passage through the atmosphere, but those weighing more than a few kilograms reach the surface with their chemical content virtually unaltered.

How simple organic molecules form in interstellar space is considered by Dr. David Williams in the article "Interstellar Molecules" (*Physics Bulletin,* 1979, p. 387). He notes that gas atoms and molecules are present with extremely low density (about 10^4 per cubic centimetre) in the clouds of outer space. Gas-phase reaction mechanisms familiar to earth-bound chemists would not apply. Following a collision of two reacting atoms or molecules, there is almost no probability that a third atom or molecule will arrive at the highly excited intermediate and carry away excess energy. If the excited complex cannot dissipate its excitation energy within a short time, it fragments and reforms the reactants.

One process that dissipates excess energy is the release of a photon of radiation. "Radiative association" is slow for neutral atoms, but occurs more rapidly if one reacting particle is an ion. An example is the proposed reaction $C^+ + H_2 \rightarrow CH_2^+ + h\nu$, which could be an important starting point for interstellar carbon chemistry.

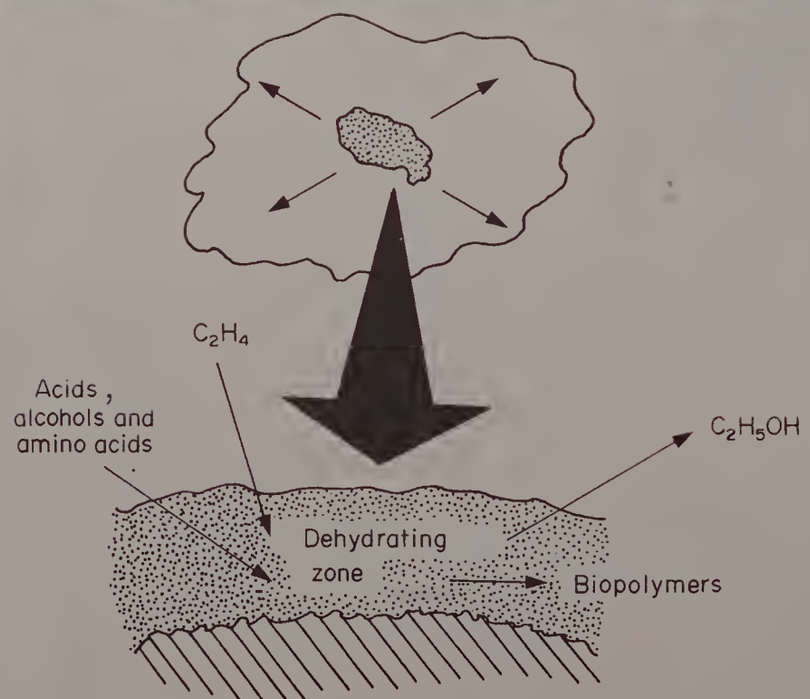
The fastest route for molecule formation is usually ion - molecule reactions. Here, product fragments carry away excitation energy of the intermediate. A curious characteristic of ion - molecule reactions is that the reaction rate usually does not vary much with temperature. The greater number of collisions at higher

Could these be predecessors of the first living cells? Particles of the clay mineral Halloysite form onion-like layered globules or thin flakes rolled into tubes (shown here in an electron micrograph). Such particles, when immersed in the primeval ocean of the Earth, would have certainly been an attractive substrate on which an oily hydrocarbon film could grow. *(Photograph courtesy of George Millot of the Université Louis Pasteur in France).*

temperatures is offset by enhanced ability of the colliding particles to escape the attractive force between the charged ion and the induced dipole of the molecule. One ion - molecule reaction, $D^+ + H_2 \rightarrow HD + H^+$, efficiently incorporates deuterium into molecular hydrogen. This reaction is thought to account for the thousand-fold greater production of HD than one would expect from the relative scarcity of deuterium.

But how does molecular hydrogen form initially? Neither radiative association or ion - molecule reactions can account for the formation of H_2 from hydrogen atoms, and hydrogen is by far the most abundant molecule found in our galaxy. To explain the presence of H_2, it is postulated that atomic hydrogen reacts on the surface of interstellar dust grains. Interstellar dust might catalyze the formation of other molecules as well, although this is a subject of contention. It has even been suggested that hydrogen, carbon monoxide and ammonia react on instellar dust particles of nickel - iron oxides and hydrated silica, much the same as these gases form synthetic fuel oil in the Fischer - Tropsch reaction. Despite the controversy about the role of dust particles in promoting reactions, there is little doubt that dust particles protect molecules from exposure to ultraviolet radiation. Without this protection, molecules would dissociate within 10 - 100 years, a very short time by galactic standards.

Laboratory researchers and theoretical chemists have been able to demonstrate convincingly that amino acids *could* have been produced in the primitive atmosphere of earth, or in outer space. However, there is no proof that



The predecessor of the first living cell might have been a thin hydrocarbon film growing outward along the surface of an inorganic mineral particle. The surface of the particle would have served as catalyst for the energy-producing reaction of the organism—perhaps the dehydration of ethene. Dehydrating conditions created within the organic layer could have provided the driving force for the synthesis of esters and polypeptides, forming additional organic material for growth along the particle surface.

amino acids were a vital component in the first organisms, or even that they were necessary at all for life to originate. Of course, amino acids are the basic constituents of proteins and are absolutely essential to life in its present form, but the various functions now served by proteins could have been performed in other, less efficient ways. The first organism would only need to function well enough to survive. A considerable evolutionary advantage would then be available to the first organism that synthesized protein, and the use of protein would be propagated and perfected in succeeding generations. Billions of years later, no trace would remain of the first crude biological processes, even though these would have been an all-important stepping stone without which present life forms would probably never have come into existence.

The first organisms, from which higher life later evolved, could have functioned by exploiting inorganic chemical processes that had not yet reached equilibrium. Such cells would carry out the reaction faster than it would otherwise occur in the environment. Energy liberated by the reaction would be utilized to maintain the organism's structure and allow it to grow. To bring this about, the energy-producing reaction would induce a concentration gradient or change in chemical environment to drive the chemical production of cell material.

What would such an organism be like? Dr. S. P. S. Andrew speculates in his article "Designing the first organism" (*Chemistry in Britain,* November 1979). Firstly, Dr. Andrew emphasizes that conditions on Earth were quite different from those at present. The concentration of the atmosphere was controlled almost entirely by volcanic outgassing. He speculates that because the Earth had a thinner crust, outgassing temperatures were higher. As a result, it is reasonable to assume that appreciable quantities of CO, SO_2 and alkenes were released. These gases might have been nutrients (reactants) providing energy for the first crude organisms. Large amounts of (now condensed) water vapor would likely have contributed to make the total atmospheric pressure several times its present value. The first oceans could thus have condensed at temperatures well above the normal boiling point of water, perhaps as high as 130°C.

One possible food energy source for the first organisms would have been the hydration of ethene; $C_2H_4 + H_2O \rightarrow C_2H_5OH$. Dr. Andrew envisions that this reaction occurred on the surface of fine particles of precipitated calcium phosphate (having some catalyst activity at the 130° ocean temperature). A hydrocarbon film adsorbed on the surface of the particle would reduce the accessibility of water to the particle, but would allow free diffusion of ethene and ethanol. Floating near the ocean surface, the hydrocarbon-coated particle would absorb ethene from the surrounding water, and excrete ethanol. The hydration reaction would create a nearly water-free environment and drive the synthesis of esters, polypeptides and other dehydration reactions leading to macromolecules. Insoluble high-molecular weight products would remain in the floc, causing it to grow, and modifying its structure.

Another reaction which might have provided the organism with energy is the reduction of sulfur dioxide: $SO_2 + 3H_2 \rightarrow H_2S + 2H_2S$. This reaction causes a change in pH and precipitates metal sulfides. Indeed, sulfate-reducing bacteria still exist in our environment and derive their energy needs in this way.

Biotechnology opens route from biomass to fuel

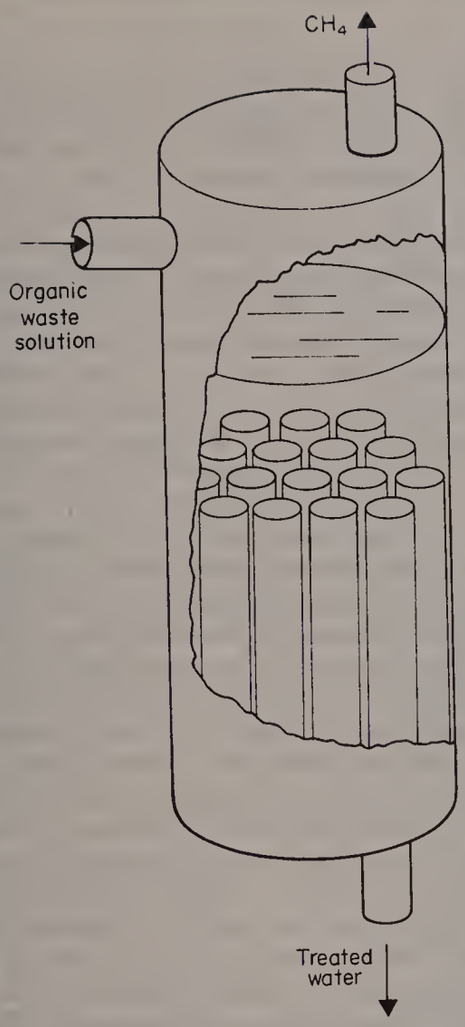
As part of the expected switch from petroleum to alternative energy supplies, biomass (fast-growing plants, agricultural waste and sewage) will play a significant part. Carbohydrates, such as cellulose, represent an enormous reservoir of renewable raw materials. It is estimated that approximately 10^{11} tons of cellulose are formed by photosynthesis on a global basis each year. Less than 10% of this is used for food, wood and paper; the remainder represents a potentially large energy resource which can be converted to high-grade fuels such as hydrogen, methane, methanol and ethanol. In upgrading biomass to these gaseous and liquid fuels, microorganisms will play a key role.

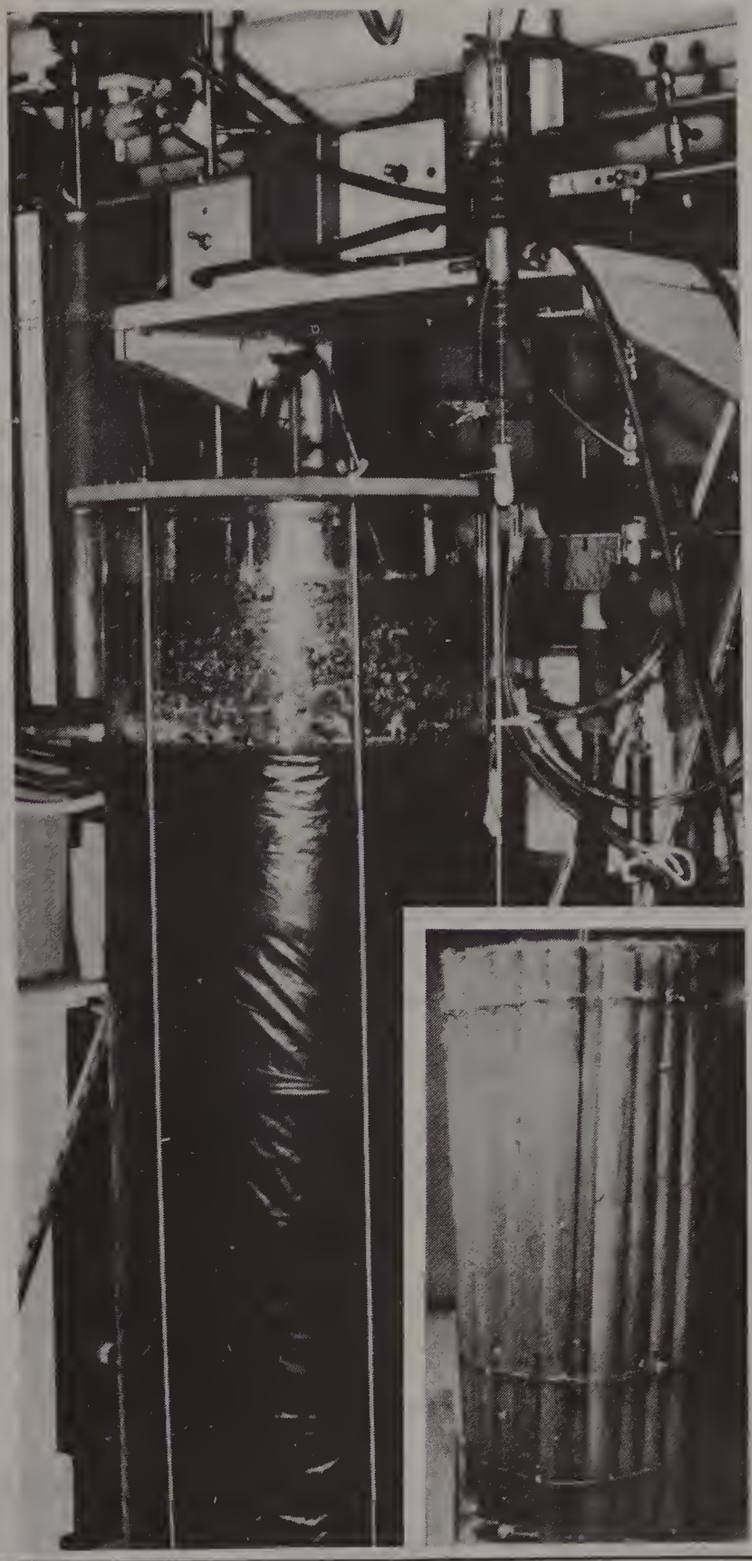
Of all energy conversion processes, microbial energy production has been studied the least. For example, hydrogen is a major product of the degradation of carbohydrates and other organic compounds by a wide variety of microorganisms, yet is has not been intensively studied with the objective of developing a commercial process. What has been learned in studies of microbial hydrogen production has often been incidental or secondary to other objectives. Little effort has been expended on optimizing conditions for producing hydrogen gas from cheap carbohydrate raw materials. Indeed, considerable improvements in hydrogen yield are to be expected from selection of optimal growth conditions and type of microorganism. That is the conclusion of Drs. J. E. Zajic, A. Margaritis and J. D. Brosseau in the review article *Microbial Hydrogen Production from Replenishable Resources,* appearing in the International Journal of Hydrogen Energy (No. 5, 1979, p.385). Their paper discusses the hydrogen yields that have been obtained so far, the mechanism of microbial breakdown of carbohydrates, and evidence pointing towards further improvement in yield of fuel gas to be expected. Prof. Zajic is serving as Chairman of the organizing committee of the forthcoming IUPAC-sponsored International Fermentation Symposium (to be held in July of this year) and is a member of the IUPAC Commission on Biotechnology.

In their paper, Prof. Zajic and his coworkers examined the production of hydrogen by microbial degradation of glucose (the monomer of which cellulose is composed). They noted that the highest hydrogen yield obtained so far is 4 moles of hydrogen gas for each mole of glucose. Carbon dioxide is liberated simultaneously with hydrogen.

Other microbial processes can convert biomass into liquid fuels. The fermentation of sugars into ethanol motor fuel has been the focus of much attention and controversy, and proponents of "gasohol" (gasoline-alcohol mixture for motor fuel) have made considerable progress in the last few years. Ethanol is now being produced from corn starch and used as a motor fuel extender in the "corn belt" of the United States. Brazil has the most advanced program for reducing petroleum imports by utilizing ethanol (made from sugar cane) as motor fuel. It is in countries like Brazil, with a large land area, high photosynthetic production and low population density, that biomass-derived fuel could have the greatest impact, though it could not of itself provide a complete solution. The limitations of biomass-derived fuels are made clear by Elmer Gaden, Jr in the article published in *Pure & Applied Chemistry* (Jan 1980 issue), *Prospects for Biotechnology in a Resource-Limited World.* In his paper, presented to the IUPAC Congress last August, Dr. Gaden noted that the use of gasohol fuel will result in a net energy gain only if high crop yields can be obtained without intensive use of fertilizer and machine cultivation. Otherwise, the energy consumed in producing fertilizer, harvesting crops and distilling the alcohol might actually exceed the energy content of the ethanol. And even if the overall energy balance for ethanol production were favorable, the ethanol produced would replace only a fraction of present liquid fuel consumption. For example, the amount of alcohol that could be produced from *all* cereal grains grown in the United States could replace only about 15% of US gasoline consumption.

Dr. Gaden concludes that for the US he "cannot conceive of any large-scale use of biomass-derived fuel in the near future or, for that matter, ever. I do however, believe that ethanol produced from locally available, renewable resources . . . (could) meet local needs . . . in specific regions, both of the industrialized and developing worlds". He points out that fermentation technology is easily adapted to small-scale units, and predicts that small fermentation plants—compatible with local resources—will be practical fuel suppliers for local city buses, farm equipment and municipal vehicles.





Methane is produced from organic waste at an accelerated rate in a new fermenter vessel developed at Canada's National Research Council, depicted here in photographs and a cutaway view. Methanogenic bacteria, which grow very slowly, adhere to the inside surface of tubes or channels and are retained in the reactor. By admitting waste water from above, rather than below as is done by other research groups, problems of channelling and plugging are avoided. The 40-litre reactor shown here is covered with plastic to keep light from the bacteria-lined tubes within. *(Photographs courtesy of Dr. L. van den Berg, NRC, Canada.)*

Anaerobic bacteria convert biomass to methane

Another area where biotechnology is moving towards wide commercial use is the generation of methane from biomass. Here too, basic scientific understanding is far from complete.

A small group of methanogenic bacteria are responsible for the formation of methane during the decay of organic matter. Normally, these bacteria are found in swamps, lake sediments and other environments where organic matter decomposes in the absence of air. In the initial stages of breakdown, other types of bacteria release enzymes that break

down cellulose and other organic polymers, forming sugars. These in turn are fermented to fatty acids, alcohols, carbon dioxide and hydrogen. Acetate, a preferred food for methanogenic bacteria, is first converted to carbon dioxide, which is reduced to methane with molecular hydrogen. It has been demonstrated that methane formation depends upon the presence of hydrogen gas. When methanogenic bacteria are inhibited, hydrogen gas accumulates during anaerobic digestion.

Production of methane from manure and agricultural waste has been practised on a limited scale for some decades in a few developing countries, and is now being adopted on a more extensive scale. Applications of biomass-derived methane (biogas) in developing countries, and efforts to develop high-technology methane generators, have been summarized in *Chemistry International* (1979), issue no. 3. Since then, several promising new developments have emerged. These appear likely to enhance the viability of methane generation as a source of fuel gas, fertilizer and as a superior waste disposal method.

Several chemical companies have developed anaerobic digestion processes which promise improved waste water treatment at starch manufacturing plants, paper mills, breweries and other chemical plants producing biodegradable waste. The generation of methane offsets the energy required to operate the waste treatment system, and can even provide a net energy output. Sludge, a waste byproduct requiring disposal, is only one-tenth as much as that produced by conventional (aerobic) treatment methods. These improved processes rely on recycling digested sludge (solid particles of bacterial growth) from the digestor effluent, and mixing it with incoming waste. In this way, the effective retention time of the bacteria is much longer than that of the liquid, overcoming the slow growth which is characteristic of all methanogenic bacteria.

A similar approach is being pursued at Canada's National Research Council, where researchers have developed a fermentation vessel that produces up to ten times more methane than conventional fermenters of the same size. The technique (reported in the NRC publication *Science Dimension*, No.3, 1979), utilizes the adhesion of methanogenic bacteria to the internal surface of tubes or channels (glass, plastic and baked clay have been used). Small-diameter tubes are most efficient, and could in principle be clustered together to form a large-scale fermenter. Preliminary research has been conducted with a laboratory-scale fermenter, whose daily methane output is five times the fermenter volume. By contrast, a conventional "Gobar" biogas plant, used to provide cooking gas in Indian villages, yields less than half its volume in methane each day. If such improvements can be duplicated in larger high-technology digestion plants, the capability of anaerobic digestion can be more fully exploited.

Conventional industrial waste treatment requires considerable energy—typically about one Watt-hour for each gram of Chemical Oxygen Demand removed from the waste stream. However, production of methane by anaerobic treatment processes drastically reduces the net energy consumpion, and can even yield a net energy output. Researchers at the Celanese Corporation have recently developed an anaerobic digestion process to treat effluent from petrochemical plants. The process, in commercial use (above) since 1977 at a chemical plant in Vernon, Texas (USA), exposes the waste stream to methanogenic bacteria lining a packing material inside a large tank. After digestion, some treated effluent is recycled and mixed with incoming raw waste. This protects the sensitive bacteria from sudden changes in acidity or toxic compounds released into the waste stream. *(Photograph courtesy of Ford, Bacon & Davis Texas.)*

Heavy metals: the good, the bad & the ugly

Heavy metal pollution is one of those subjects that immediately incites a showdown between industrialists and environmentalists. Just how serious a problem it is, and what should be done about it, are frequently a matter of dispute. Yet, a great deal of information is now available, and much can be said with confidence about the origin and effects of lead, mercury, cadmium and other heavy metal pollutants.

Lead has been known to be toxic since the ancient Romans built extensive aqueduct systems and utilized lead pipes to carry water (the word "plumbing" is derived from the same Roman root as the chemical symbol Pb). Because of the ductility and corrosion resistance of lead, it has been widely used for piping until the 20th century. Most lead piping has been replaced, but in the last few decades another important source of lead pollution has emerged: anti-knock compounds used in motor fuel. It presents a two-sided problem. On the one hand, the lead content of vehicle exhaust is a regional problem, with high concentrations accumulating in the air of congested cities. On the other hand, airborne lead is a global problem, as fine particles are carried by the atmosphere and deposited thousands of kilometres from the source.

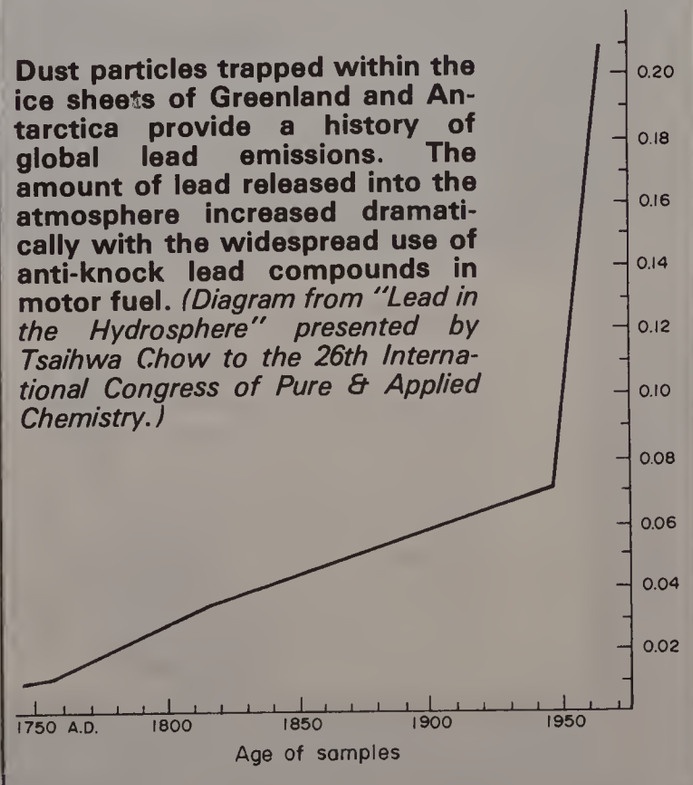
Recent findings on the chemical fate of heavy metals were presented at a symposium on *Heavy Metals in the Environment,* held last September at the Autumn meeting of the UK Chemical Society. Dr. Roy M. Harrison (of the University of Lancaster) focussed upon the anti-knock compounds tetra-methyl and tetra-ethyl lead as by far the single largest source of atmospheric lead pollution, and ultimately, one of the major sources of lead pollution of surface waters. These compounds were first introduced as fuel additives in the 1920's, and consumed in large amounts beginning in the 1940's. Several million tons of lead have been released in vehicle exhaust in the United States alone. A recent trend away from lead-containing anti-knock compounds has contained their useage in the US, but this could be offset by growing use of motor fuel in other countries.

What happens to the large amounts of lead anti-knock compounds used in motor fuel? During combustion, they react with brominated and chlorinated hydrocarbon additives (these are added as scavengers to prevent lead oxide deposits in the combustion chamber). The main lead-containing component in vehicle exhaust is PbBrCl, formed in small particles averaging 0.01-0.02 microns diameter. In air, these particles react with naturally-occurring droplets of ammonium sulfate and dilute sulfuric acid. This reaction produces the lead salts found in urban air, of which the most abundant is lead ammonium sulfate. Some lead-containing particles diffuse to the soil along the roadside and are responsible for high lead concentrations of soil adjacent to main roads. But many of the lead particles are carried by air currents and spread around the globe.

Lead-containing dust which has been precipitated by snowfall in polar regions provides a clear record of man-made lead emissions. Dusts deposited within the ice layer of Northern Greenland and the Antarctic continent have remained unmixed and undisturbed for thousands of years. Greenland snow deposited at the beginning of the European industrial revolution (about 1750) contains 0.011 ppb lead—a concentration already more than 25 times the natural level. Lead content of Greenland snow tripled during the 65 year period from 1750 - 1815, and then doubled from 1815 - 1933. Since then, the lead concentration rose at an even faster rate to well over 500 times the natural level. The increase in lead concentration prior to 1940 is attributed primarily to coal burning and lead smelting, while combustion of alkyl lead derivatives in automotive fuels accounts for the rapid rise after 1940. However, data based on lead accumulation in Greenland ice is questioned by some, including Dr. Harrison. He points out to *Chemistry In-*

LEAD CONTENT OF GREENLAND SNOW (parts-per-billion)

Dust particles trapped within the ice sheets of Greenland and Antarctica provide a history of global lead emissions. The amount of lead released into the atmosphere increased dramatically with the widespread use of anti-knock lead compounds in motor fuel. *(Diagram from "Lead in the Hydrosphere" presented by Tsaihwa Chow to the 26th International Congress of Pure & Applied Chemistry.)*



ternational that some of the lead contamination of upper ice layers may have originated from a local military base.

There are many views about whether exposure of the world's population to low levels of lead or other heavy metals constitutes a real health hazard. One outlook was presented at the same symposium by Dr. G. S. Fell (of the Dept. of Pathological Biochemistry, University of Glasgow in Scotland). He believes that concern should not be focussed on low-level chronic exposure to heavy metals, but on clearly dangerous exposure of certain individuals to high concentrations. One obvious example is occupational exposure of workers involved with metal refining. In one Glasgow factory, coppersmiths who had undergone long-term exposure to cadmium fumes during brazing operations had greatly increased cadmium concentrations in their blood and urine, and had apparently suffered kidney damage. However, the main source of cadmium exposure *in the general population* is not industrial pollution of the environment, but is cigarette smoking.

Other examples where people are exposed to dangerous—even fatal—levels of heavy metals may not be apparent at all. Medical treatment is one area where high metal concentrations can be overlooked with deadly consequences. Aluminium is not normally considered a toxic metal, as it is rapidly excreted during normal kidney function. However, high concentrations of aluminium in local water supplies have caused at least 15 deaths among patients undergoing hemodialysis treatment for kidney failure. In areas where alum was used as a flocculation agent to treat water supplies, aluminium ions entered the patient's blood through the hemodialysis membrane, could not be excreted, and accumulated to lethal levels. This is one example of how a metal, normally thought to be non-toxic, can be a serious health hazard.

Indeed, Dr. Fell believes it is misleading to classify any metal as "toxic" or an "essential" nutrient. Even the traditional "toxic" elements as arsenic, cadmium and lead, he points out, have been shown to be necessary in minute amounts for normal growth and development of experimental animals.

Rather than trying to eliminate all metal emissions, Dr. Fell believes it would be more productive to ensure that the concentration of any metal in the environment falls within a "concentration window". Within this concentration range, enough will be present to avoid nutritional deficiency, but not enough to be toxic. The exact concentrations marking the border of the "concentration window" are imprecise. Concentrations at which metals are essential or toxic may vary widely with susceptibility of the individual, how it is introduced into the body, its chemical form, and the effect of diet, drugs and disease. Not least is the wide variation in heavy metal concentrations reported by different laboratories testing the same samples.

THE BILLBOARD

POSITIONS SOUGHT/AVAILABLE

Notices published here are for positions for which foreign applicants will be considered favourably; academic appointments sought by staff on sabbatical leave; and staff exchanges with other organizations. There is no charge for notices published during 1980. Notices must be no more than 100 words, and typed on the letterhead of the organization. Allow several months for publication. Final copy deadlines for the next issues are mid-June and mid-August.

ORGANOMETALLIC CHEMIST SEEKS ASSIGNMENT IN DRUG RESEARCH

Research Interests: Modifying drug molecules using organometallic groups. Demonstrated that organic changes in organometallic environments. Thereby introduced β-lactamase resistance etc. in penicillin.

Position sought should involve synthesis of organometallic compounds which might lead to improved drugs and probes elucidating drug action. Teaching responsibilities acceptable. Fluent in English. Sabbatical, visiting or contract assignment 1-3 years, starting Oct. 1981 in university or research organization. Location: Open. Full salary/Fellowship, travel funds requested. Contact Prof. J.K.P. Ariyaratne, Chemistry Dept, Univ. of Kelaniya, Kelaniya, Sri Lanka.

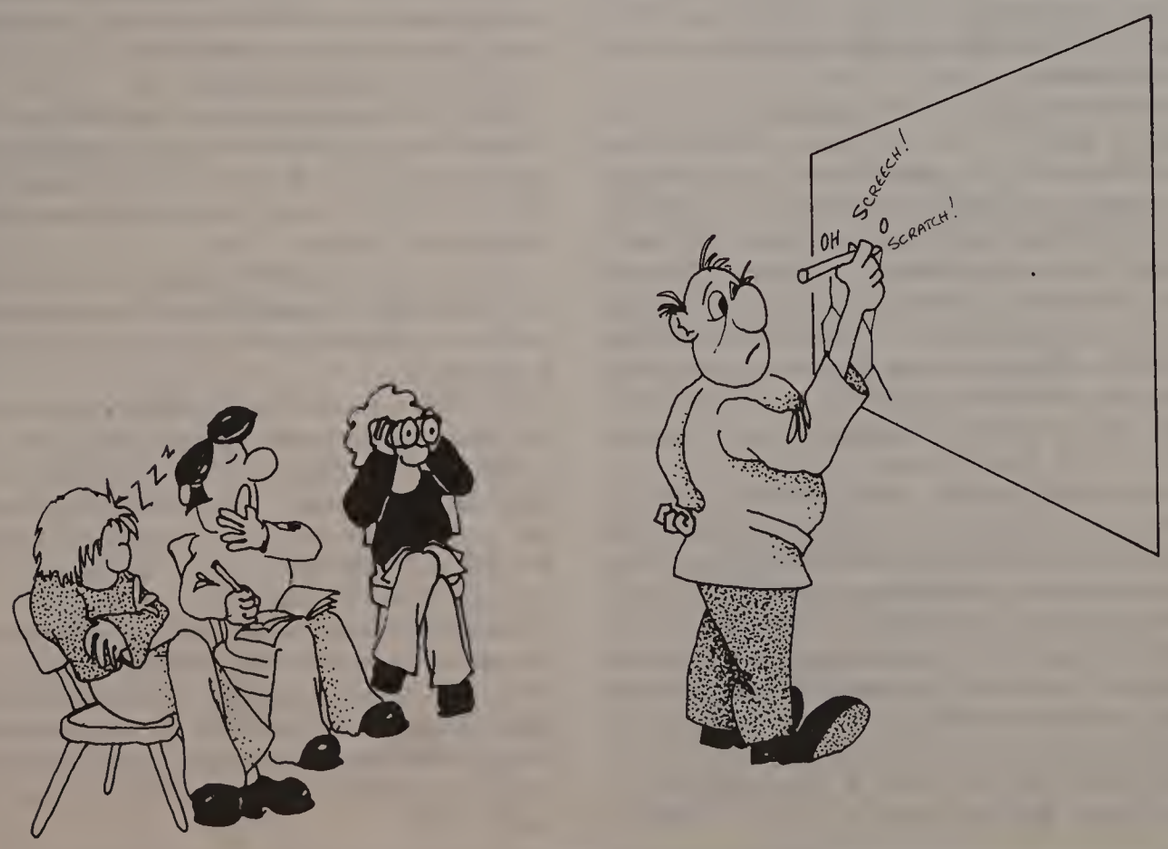
Presenting your research results

A manual for chemists presenting papers at international chemistry conferences

No method of presenting research results of individual views can have more impact, and arouse more attention, than a face-to-face presentation at a major chemistry conference—be it as a plenary lecture, poster presentation or a short talk. But on the other hand, nothing can be more boring than a speaker who has not organized his material, shows slides so crammed with data as to obscure meaningful conclusions, and drones on past his alloted time in a monotonous voice.

The following article is a guide to help you present your results, conclusions and views at chemistry conferences. It provides helpful hints in preparing your presentation and alerts you to common pitfalls to be avoided. Many of the suggestions are simple... perhaps obvious. Yet, these same mistakes are repeated at nearly every conference, undermining the interest and understanding of the audience. Attention to these points could make your work better understood and recognized by chemists throughout the world.

The guide is based upon three essays written by Guy Ourisson, secretary-general of the IUPAC and Professor at the Institut de Chimie of the Université Louis Pasteur in Strasbourg, France.



I. SPEAK

Speak . . . but not yet. You have just been given the word by your chairman. Wait until your projectionist has prepared your slides. Wait until you can safely speak, then start.

Start by stating what you are going to talk about, then talk about it, then summarize what you have been talking about.

Never assume that anybody in the audience is a fan of yours, knows your work, is familiar with your publications, and expects you to divulge only brand new results. Always place your subject in a general perspective and explain why you have taken it up. Describe briefly your methods and results, and describe clearly your conclusions.

During your lecture, as well as during the discussion, talk to the person sitting on the farthest bench, not to your chairman or your supporters in the front seats. You can safely assume that this back-bencher is not competent in your field, but that he hopes you will make him understand your work. Make sure he hears and understands you. Never speak to the blackboard. If your lecture room is equipped with microphone and loudspeakers, avoid the ear-piecing squeak obtained when noise from one loudspeaker is picked up by the mike: don't let the microphone come close to the nearest loud-speaker. Always speak near, but away from, the mike, and never, never touch it, move it, or drum on it. Or else, forsake the microphone and speak LOUDLY.

If your lecture is to be simultaneously translated, contact the translator before your lecture. Give him a related text or list of most specialized words you are going to use. Offer him your help in advance.

Never read a text: nothing can be more efficiently boring. If you do not feel secure, use slides *with text* to prop you up, but again do not read them aloud but comment on them. Most likely, everybody in the audience is literate.

When said in public, some words leave no mark in anybody's mind. Never use them without having written them on the blackboard or on a slide. Foreign family names can be pronounced in so many different ways. Dates and numerical values too should be written: in an international audience, some will mistake fifty-two for tweny five (fünf und zwanzig). Anyway, it is best not to use numerical values unless they pertain *directly* to your discussion. Otherwise, who in the audience would care for the value of a melting point, specific rotation or nmr chemical shift?

Another don't: never, never utter a systematic IUPAC name; it is bad taste. IUPAC names are not intended to be used in that way. Passport numbers are also systematic, unambiguous, useful descriptors of individuals, but who would call his girl friend by her passport number? And anyway, the audience will be informed just as well by saying "this unsaturated ketone..." while pointing to a formula on a slide or the black-board.

Stick to the allotted time. It is a good idea to rehearse your lecture once, in full, in front of critically-minded friends and a clock. It is said that a new President or Prime Minister has 100 days to show what he can do. You have 20 minutes at most. If your lecture is scheduled to last 45 minutes, the last 25 minutes will be useful only if you have managed to interest your audience in the first 20. If you are an unusually effective lecturer, nobody will notice if you overshoot the limit by a few minutes. But if you babble well past the limit, you are sure to antagonize the next speaker, the session chairman, and the rest of the audience. Obey automatic warning lights if they are in use, or use an alarm watch.

Now a few words about light arrows, which are meant to show one point on a slide, and then disappear. An illuminated arrow will be more apparent on any *other* surface than a bright projection screen: turn it off when not in use. Otherwise, you are likely to draw the attention of the audience around the lecture hall, across the ceiling and onto a pot plant.

When you reach the end of your lecture, conclude briefly, clearly and *explicitly*. The audience must know when to applaud, or at worst, when to wake up.

Finally, if you must speak in English, and if you really can't, try to enlist an English-speaking colleague to help you with your lecture, at least to correct the key words you will be using constantly throughout your talk.

II. SHOW (SLIDES)

Lecture slides are the *easiest* way to communicate information under the conditions of a conference lecture. The *best* way is probably with blackboard and chalk, but their use at a symposium requires experience, ample blackboard space, and a suitable lecture topic. It is commendable when done well, but is generally not recommended.

Slides are invaluable to highlight important points of your lecture and show material which could not easily be explained. But slides should not normally be used to reproduce what you say, and never should be read on the screen.

Lecture slides must be legible and understandable. Any slide which cannot be read by everyone in the audience, including those in the back row, should not be projected.

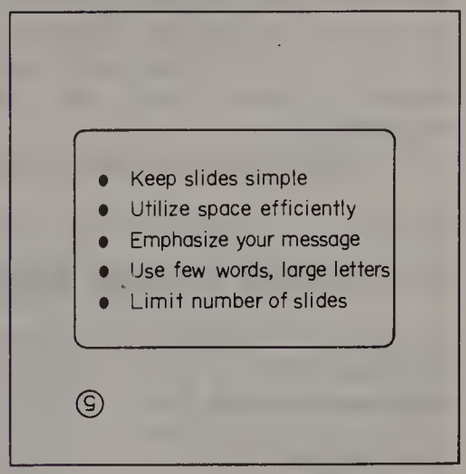
The first condition for legibility is that the entire slide must be projected on the screen. This sounds trivial, but it is common for lecturers to insert "vertical" slides amongst those oriented horizontally, and project these partly on the ceiling. This may be avoided by preparing all slides "landscape" fashion, to be projected horizontally.

Another condition for legibility is that lettering should be large and lines should be thick (thicker than for a printed figure). Any slide which cannot be read with the naked eye when held in your hand will probably not be legible when projected on a screen. This is a stringent test for legibility; but it is simple, and it works.

Viewing this slide from a distance of about 25 cm gives an indication of how it might appear on a projector screen from the rear seats of a lecture room.

Guidelines for preparing good slides are offered in "Preparation of Slides; A Guide for Authors", by the International Federation of Automatic Control. Among their recommendations:

(1) A good slide should convey a single, significant message to support the oral presentation.
(2) It is usually advantageous to simplify tables, graphs, diagrams and drawings. Additional information may be presented orally.
(3) Tables are recommended only if the information cannot be portrayed graphically.
(4) Do not reproduce material from printed publications unless it is suitable. In most cases, printed illustrations contain too many details.
(5) Use a lettering guide (stencil) for text. Allow additional spacing between words and lines.


• Keep slides simple
• Utilize space efficiently
• Emphasize your message
• Use few words, large letters
• Limit number of slides
5

Another helpful suggestion is to put a numbered self-adhesive label on the lower left-hand corner of the slide (when the slide is viewed as it is to appear on the screen). This makes it simple to keep the slides in order, and ensure that the slide will be projected right-side up. When the slide is correctly loaded into the projector, the label will be covered by the projectionist's right-hand thumb.

For all art-work, use a standard A4 page (180 x 240 mm), never a larger format. On this size page, you can draw formulas of the correct size using commercial stencils (made by such companies as Verlag Chemie, Merck, Darmstadt, etc).

Restrict the amount of information on each slide. Aim at "one information bit" per slide, and do not hesitate to split a set of data onto two slides. To avoid cramming too much information on each slide, you should limit yourself to a maximum of 20 - 25 words per slide.

Do not include any information on which you will not comment—nomenclature, melting points, bibliographic references. Think twice before you show an n.m.r. spectrum or a chromatogram (is it really novel?) Trim your slides of unnecessary "noise" (information with no apparent purpose). Never show tables of figures (although you may safely do so if the table is so simple as to comply with the 20 - 25 word/slide limit).

Legibility does not imply professional artwork, although modern transferable lettering (such as Letraset, Decadry, etc) allows chemists to make drawings and legends with a professional look. Casual, free-style lettering and drawings can be as effective and much quicker to prepare, but you must have readable handwriting and some deftness at free-hand art. Try it once, and have it evaluated by friends before you expose it to your conference audience.

Slides are especially valuable if you are about to give your lecture in a language you have not fully mastered. In a few lines, you can summarize your problem, your methods, your results, and your conclusions. Grammatical errors can be eliminated beforehand by having slides checked and corrected. Your audience will find it much easier to follow your talk.

Different styles of slides each present advantages and drawbacks. For example, slides with black figures on a white background show dust more than white-on-black slides, but are easier to read. The major limitation on quality of any slide system is the experience, equipment and care of the photographer. Consult him; he will know which type of material will reproduce best and be most legible. You might also read several articles that provide guidance (the pamphlet "Slides with a purpose" is available free-of-charge from Dept. 55Z, Kokak Inc, Rochester NY 14650, U.S.A.).

The same slide may be needed twice, or more, during your talk. For slides you expect to show repeatedly, have two or more copies prepared rather than hope the projectionist will be able to find "slide 15" in the dark.

Identify the orientation of your slides with a clearly-seen dot or label on the frame, easily visible in the dark. This is absolutely necessary if only a manual projector is available, and could be helpful even if an automatic projector is used.

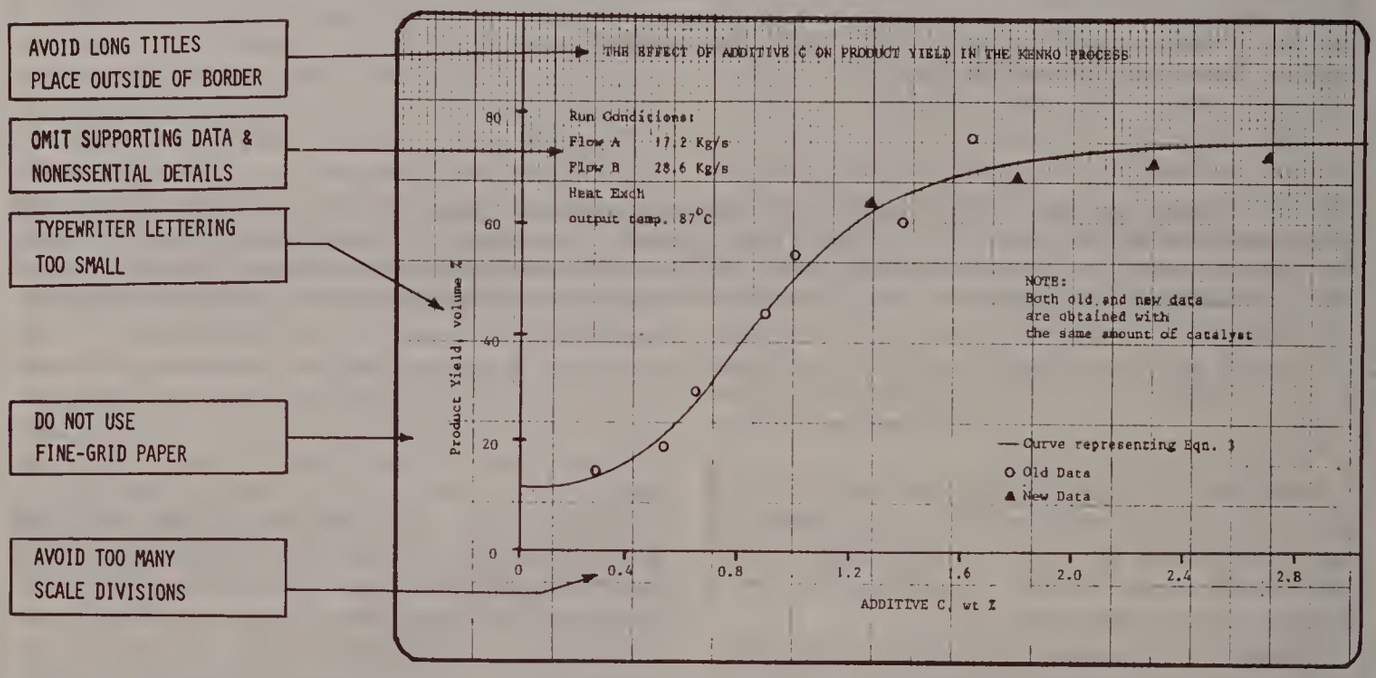
Well before your lecture, contact the people in charge of the lecture room. Introduce yourself to the projectionist; much of your success will depend upon him. Ask how he prefers you to call for the next slide, and check which trays are available. Place your slides *yourself* into the trays, checking their orientation, and deciding whether complete darkness or dimmed lights are preferable. Check the quality and size of the image on the screen. Then, if the slides prove unacceptable for the available conditions, your talk can still be salvaged with an overhead projector or blackboard and chalk.

It is amazing that even some well-seasoned lecturers are apparently quite happy to let a bored pro-

jectionist ruin their presentation by showing slides improperly focussed, in the incorrect order, and with repeated pleas for the next slide. Even worse is the time and attention of the audience dissipated in exploring the seven wrong orientations which are possible for a slide, before the correct one is discovered by chance. Such problems are usually avoided by discussing your slides with the projectionist beforehand.

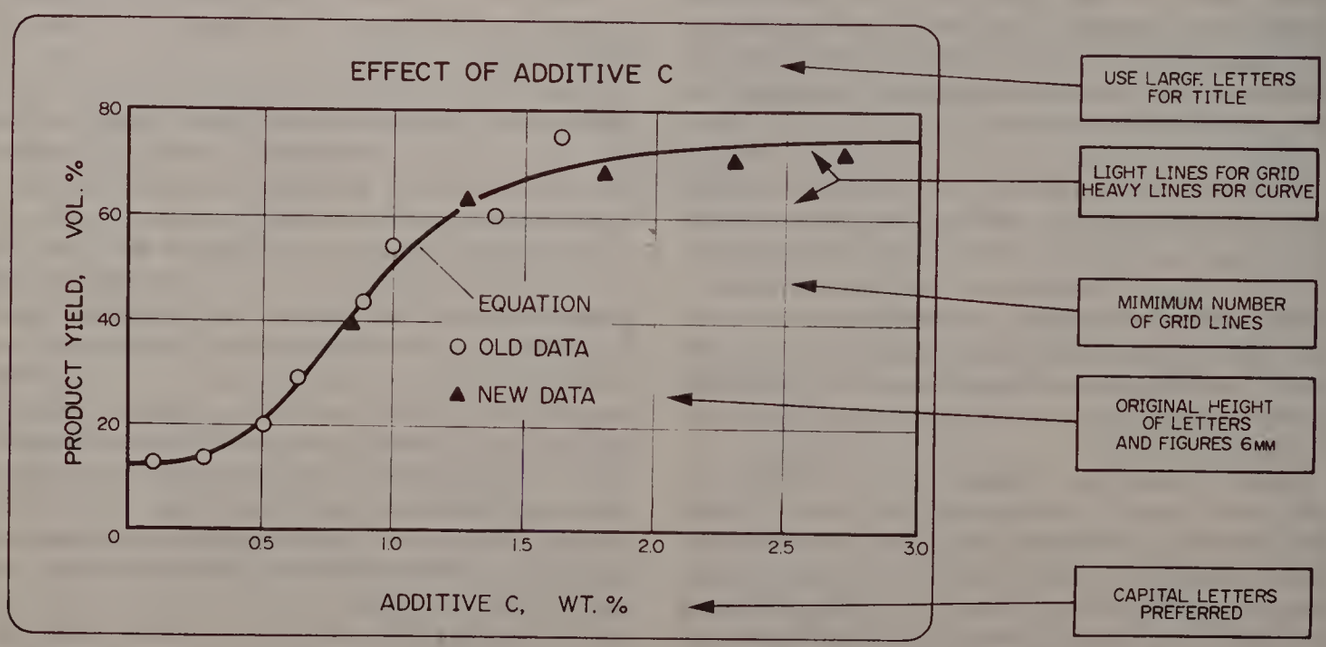
The most likely point during a symposium for major trouble is the Opening Lecture. It is then that the conference organizers are likely to discover that the screen is too small, there is no coloured chalk, and no spare projector bulb, the lights cannot be dimmed, or the microphone does not work. Do not despair! If you are the opening lecturer, you need no advice. No doubt, your ability to survive such ordeals has been a major factor contributing to your recognition and high regard to the chemical community, and to your invitation to present a conference lecture.

Example of a **poor slide** illustration



The two slide drawings shown here depict the same material, but the one below has been redrawn for simplification and clarity. Explanatory details and supporting data that have been omitted can be presented verbally if necessary or if requested. *(Adapted from "Preparation of Slides: A Guide for Authors".)*

Example of a **good slide** illustration

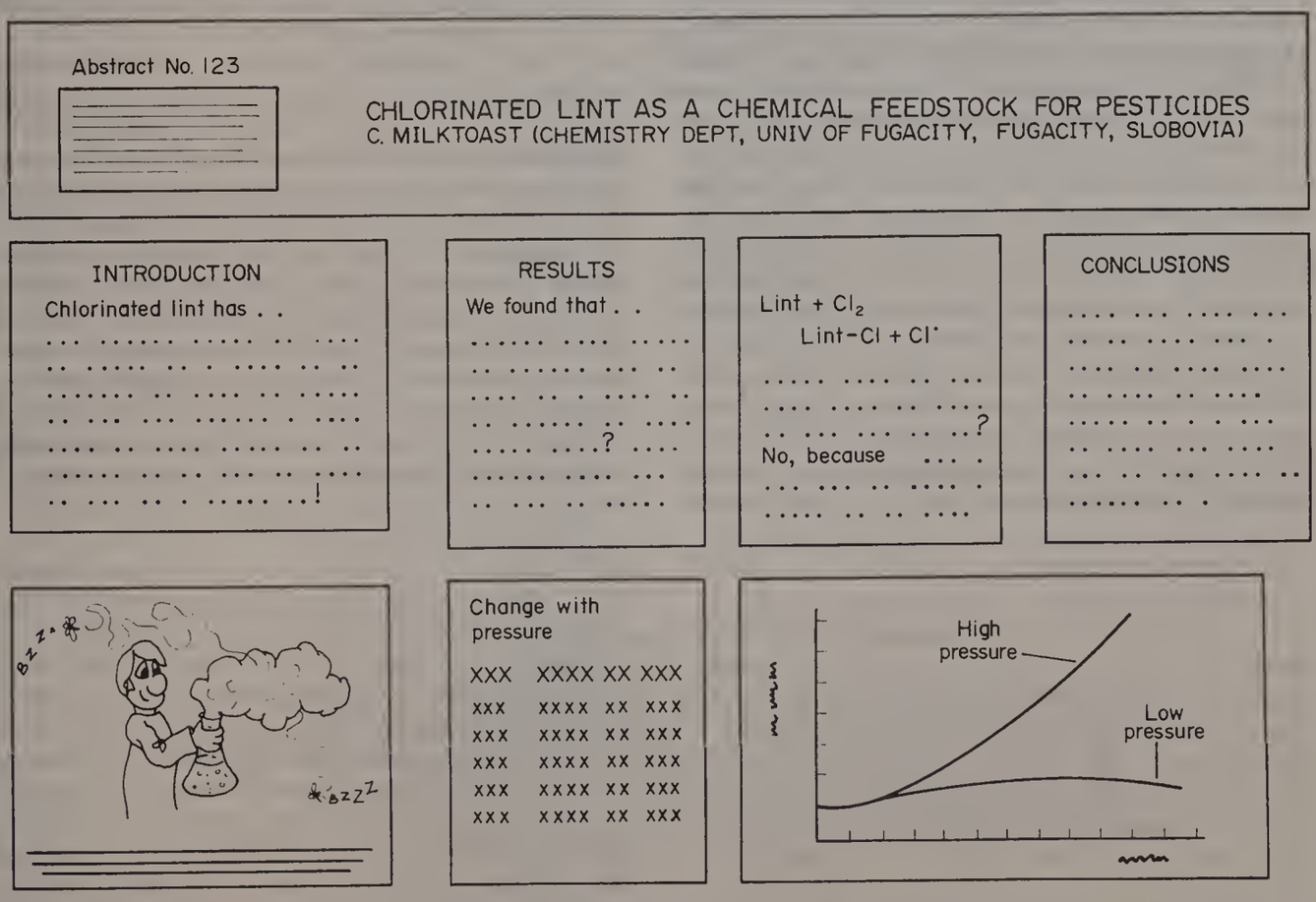


III. DISPLAY (POSTERS)

Poster sessions have been gaining wide acceptance for communicating information and engendering discussion at conferences, providing a viable alternative to formal short talks. They provide much more opportunity for casual discussion and for authors to try original presentation methods. Authors can exhibit samples of key substances, data, published papers, photographs of their apparatus, of field experiments, or even of themselves. It is important to recognize that poster sessions are *not* relegated for communicating second-rate research, but allow research interests to be discussed individually or in small groups.

Most of the charts, drawings and illustrations used in a poster display might be very similar to those which would be used to make slides—although they are generally cruder and are drawn with heavier lines. Illustrations need not—in fact, should not—be "arty". Keep illustrative material simple. Simple use of colour can add emphasis effectively. Diagrams should not be drawn on heavy board, as these may be difficult to mount on poster boards. You might find it useful to have on hand a tablet of sketch paper and one or two felt marking pens.

What may be included in a poster display is limited only by the imagination of the author (within the confines of the available space). Most authors begin by preparing a label containing title, names of authors and abstract number so that the display may be easily identified (a label may be provided by the conference organizers). The label might also indicate times when the authors will be available for discussion of the posters. A copy of the abstract is often displayed. Labels and illustrations are mounted on the fibreboard, generally with thumbtacks. If you need tape, it may be necessary to provide your own. It will be worthwhile to have available all applicable figures, tables and equations, even if you do not plan to display them. Posters should be prepared by the authors in advance, and should be mounted and later removed within the time periods set aside by the conference organizers. Most conferences have "poster



A poster display should briefly explain the importance of the project, essential background information, results and conclusions reached by the authors. It should be self-explanatory on its own, although the author should be prepared to present additional data and discuss his procedure. The poster should be laid out neatly, with large print for easy viewing. At a 3-metre distance of a passing viewer, the display might look something like this.

assistants'' to answer questions and help with technical problems.

Poster displays should generally be prepared so that they would be intelligible in themselves, even in the absence of the authors and without a study of the abstract. The contents of a poster may be divided into a SUMMARY (or abstract), INTRODUCTION, RESULTS and DISCUSSION. The SUMMARY should list pertinent results and conclusions. The INTRODUCTION can provide background information and state the purpose of the study in relation to previous work in this field. The RESULTS section may be divided into sub-headings, each indicating the most important finding. In general, as *few* results as possible should be included, just those necessary to validate the conclusions. A poster overloaded with findings will rarely attract attention. Indeed, there is no obligation to fill the entire available space with information! Finally, the DISCUSSION section should interpret the results and present their significance, even if speculative—summarizing the conclusions in an easily-remembered ''take-home'' form.

It is important to plan carefully the optimal utilization of the poster space. Subdivision into standard-size sections (for example, 9 sections 40 cm high 60 cm wide) might be helpful. Posters should be readable from a distance of 2 - 3 metres. Graphs and tables should have a minimum height of 20 cm.

A recommended size for labelling of figures and tables and the keyword text is 1 - 1.5 cm-high lettering. Smaller type than this, and lines thinner than 2 mm, cannot be easily seen from a distance. Ordinary-size typewritten material should never be used.

Tables and figures should be given a brief title. In a table, it is best to restrict oneself to four columns, with not more than four listings per column. Graphs should show a maximum of 3 curves. Drawing each curve in a different colour makes each distinctive, and is especially helpful if the curves cross or are close together. Graph axes should be clearly labelled and not overburdened with information. Thus, if an axis shows a range of 0 - 10 units, it is sufficient to label 0, 5 and 10. it is best to avoid too many digits as well, and it is preferable to label a graph axis with 0.5 and 1.0 Units, rather than 500 and 1000 milliunits.

The space below a table or figure can contain a *brief* text describing the pertinent conclusion drawn from the experimental results shown. This caption may also guide the viewer to the next experiment. Authors should be prepared to discuss experimental details when requested by an interested viewer, but this information should not be included in the poster caption, as is customary in published papers.

A more useful procedure is to prepare the poster display before setting off to the conference and to mount the display in your own laboratory, where it may be viewed and discussed by your colleagues, and possibly improved. While poster sessions do offer an informal environment for discussion of research projects, most viewers do not really enjoy the feeling of spontaneity that comes from an author who is seeing his poster for the first time.

A checklist for poster authors

SUMMARY
Is it concise enough to draw attention?

INTRODUCTION
Does it provide enough background to understand the purpose of the study?

RESULTS
Are there so many that the main contribution is obscured?
Does the keyword text between tables and figures serve as a good explanatory link?

DISCUSSION
Is the "take-home" format catchy enough to stimulate discussion?

TECHNOLOGY

Lettering:	Is size large enough for headings, tables, figures and keyword text?
Tables:	Does each have a brief title?
	Are there not more than 16 items?
Figures:	Does each have a Brief title?
	Are there not more than 3 curves on each graph?
	Are graph lines easily distinguishable?
	Does each graph line have a label which describes it?
	Are axes not overburdened with information?

REPRINT ORDERS
A limited number of reprints of this report are available for purchase. They may be ordered in lots of 25 at a cost of £5 (or US$10)/25 copies, including air-mail postage. Orders should be accompanied by a cheque payable to IUPAC, and sent to *Chemistry International*, IUPAC Secretariat, 2-3 Pound Way, Cowley Centre, Oxford OX4 3YF, U.K.

Leading world chemists ponder transfer of chemical know-how

Chemical technology is critically needed for development of the world's poor nations. But it has become all too clear from the past that high-technology products and expertise cannot simply be given away—they must be absorbed into the technological capabilities of the country. Massive infusions of chemical equipment have been failures; what clearly seems to be needed is a broad approach directed at upgrading all areas of chemical practice and education.

But how is this to be done, and what help is being provided by the industrialized nations? These questions were addressed repeatedly during a meeting of chemical society presidents held late last year. That meeting, held in Washington D.C., USA, was attended by representatives of 36 chemical societies and 5 international chemical associations and federations. Two themes were especially prominent among the speaker's addresses: transfer of technology, and energy supplies.

The need for transfer of technology between the industrialized and developing countries was captured succinctly by Dr. Glenn Seaborg, former president of the American Chemical Society. He observed that:

"The world has reached a stage where substantial interdependence among developed and less developed countries is essential to the fulfillment of human needs. We need to match *limited* global natural resources—the use of energy, materials, food, and water—to the requirements of a growing humanity. We need to raise the level of people's health throughout much of the world. In this process chemistry, perhaps the most utilitarian of all sciences, and chemists and chemical engineers, worldwide, must play a vital role. Such greater international cooperation, based in large part on our humanitarian instincts, inevitably, will also be essential to our own self interest. The economic future of the advanced and the developing countries are inexorably entwined."

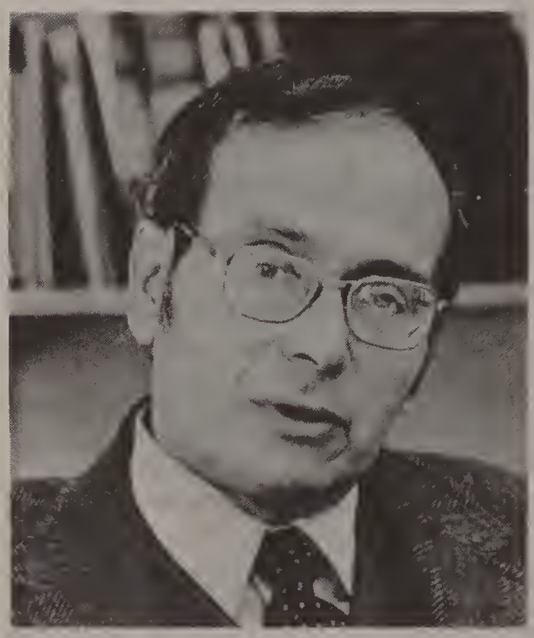
Discussion at the international gathering did not consider only a one-way transfer of technology *from* industrialized countries *to* developing nations. Common challenges and impending problems face all nations, and these will require a massive research effort in which international cooperation will be essential. It was recognized that "there are a growing number of mutual benefits to be gained by extending our exchanges of science and technology". This theme was stressed by Dr. Frank Press, Director of the Office of Science & Technology of the US Government (because of an airline delay, Dr. Press' address was read by an associate). The mutual benefits to be gained, it was stated, "include the possibility of vastly extending our energy and material resources, through new discoveries and technologies, at a time when the rising cost of those resources is drastically affecting the international economy".

"They include the possibilty of understanding, halting and perhaps reversing, a great deal of environmental change that could affect the world for generations to come—problems of soil erosion and desertification, of atmospheric carbon dioxide, of acid rain, of ocean pollution, of the destruction to tropical forests, and other impending troubles."

"They also include the possiblity of providing the developing world, with a greatly improved scientific and technology capacity, to advance their agriculture, make better use of their natural resources, develop suitable energy technologies, improve the health of their people, and build the education and information systems essential to their future success."

"First of all . . . when we talk about the developing world we must continually remind ourselves that we are talking about several things."

> "We are talking about countries that contain 70 percent of today's population, and may contain upwards of 90 percent in the decades ahead. Yet these are countries where only 4 percent of the world's research and development is conducted."
>
> "We are talking about parts of the world where 20 percent of the people live in conditions of absolute poverty, and where as many as 500 million are hungry and malnourished. Yet these are areas where less than 1 percent of the world's research and development is devoted to meeting the needs of these people"
>
> "We are talking about countries that are vastly different in their resources and needs. Some are rich in minerals. Some are mineral poor but have a wealth of biological



"Among these were the growing ideas that, for the majority of developing countries—

strengthening their scientific and technological capacities was more important than specific technological transfer;

that such capacities had to be developed before some technologies could be absorbed;

that the proper infrastructure had to be created, along with the development of human resources through education and training."

Dr. Frank Press
Director, Office of Science & Tech.
US Government

resources. Some are deserts over vast pools of petroleum, others over deep pools of fresh water. Some are just deserts."

"We are also talking about many countries in which more than half the people are under the age of 15, and where literacy and opportunity for education and employment are low".

"Perhaps just as important as all this, and other diverse features of the developing world, is the fact that its people now look to the future with ever-rising expectation—even as the expectations of the industrialized world are somewhat diminished by the pressures of the times. And we in turn are now beginning to realize, just how much our future will be tied to theirs, as the demography, economics and politics of the world change with the growth."

"The recent UN Conference on Science and Technology for Development . . . reflected some maturing and refinements in ideas and attitudes, concerning the roles of science and technology in development. Among these were the growing ideas that, for the majority of developing countries, strengthening their scientific and technological capacities was more important than specific technological transfer; that such capacities had to be developed before some technologies could be absorbed; that the proper infrastructure had to be created, along with the development of human resources through education and training."

Poor educational facilities, lack of well-qualified teachers and inadequate (often, inappropriate) textbooks are major factors inhibiting the assimilation of new chemical technology. The generally poor level of chemistry education in underveloped countries was pointed out by Prof. Armando Kapauan, President of the Chemical Society of the Philippines. He noted that "in most countries, the level of training for chemistry bears a direct correlation with the level of chemical practice".

"Chemical education and chemical practice constitute an interacting system of components in which action initiated at one point is often affected by what is happening in other parts of the system. There is no sense, for instance, in putting up laboratories equipped with the very latest high powered and expensive instrumentation when the educational system cannot adequately train people to use them and maintain them in proper working condition. Consideration of the various interactions possible argue for an evolutionary approach rather than a revolutionary one in trying to upgrade chemical practice and education, and an approach that considers concerted action in several areas rather than massive action at only one point."

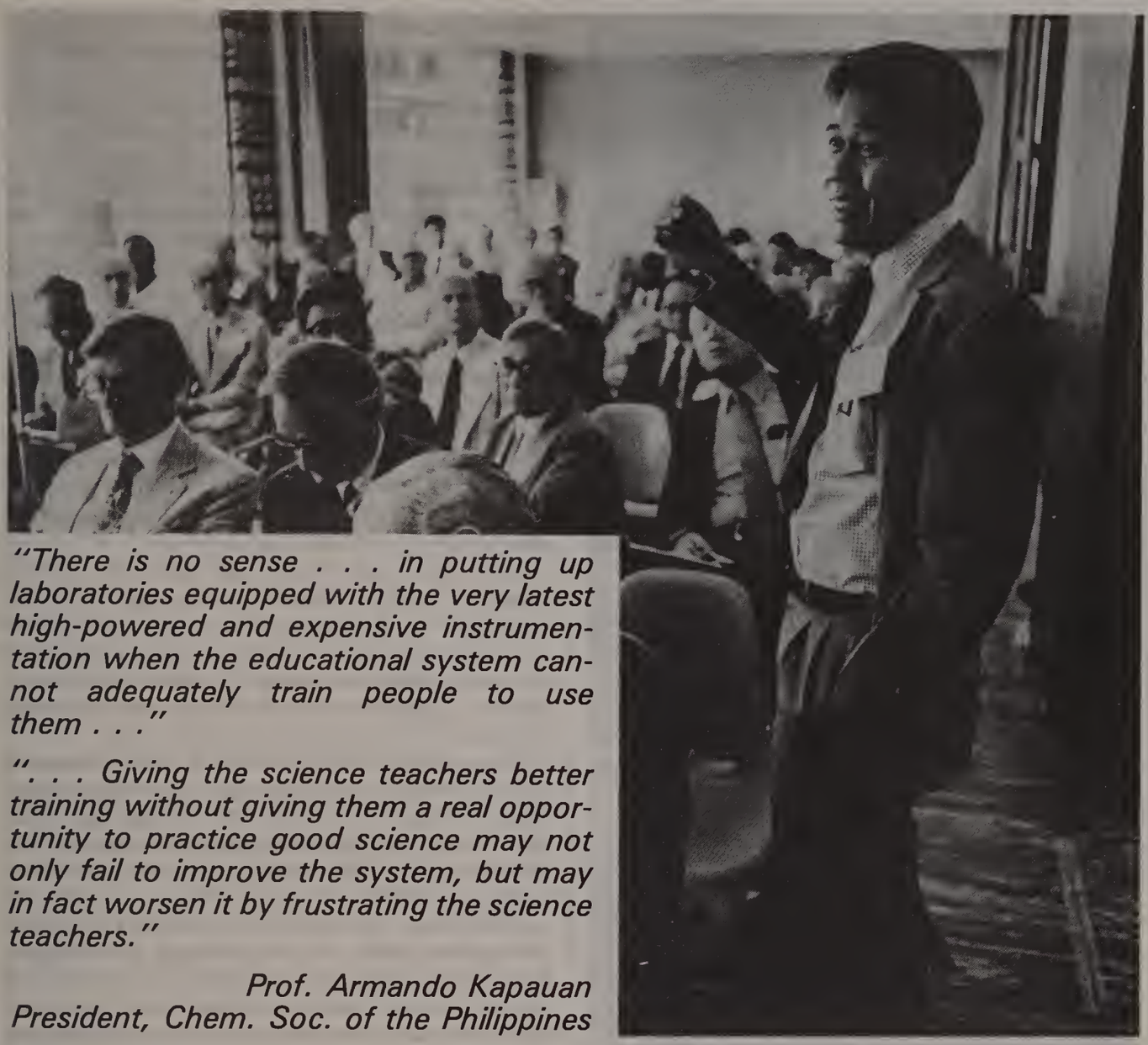
"This interactions between chemical education and practice . . . may be viewed as feedback between manpower training and utilization. Operation of this feedback can and does lead to appalling situations in chemistry in developing countries."

"The social scientists talk about the cycle of poverty, where the poor, unable to afford the means by which they could improve their incomes, remain poor—or worse, become poorer. An analogous situation develops in societies between chemical education and practice."

"This is perhaps the most obvious in the great difficulties which were (or still are) encountered in the effort to improve science teaching. . . . Where the practice of science teaching is poor, there is a tendency to produce poor science teachers, who then perpetuate (or worsen) the already poor science teaching."

"The main difficulty in trying to improve the situation is of course the fact that action aimed at only a single point in the cyclic system often fails to alter the system permanently. Thus in the above example of science teaching, giving the science teachers better training without giving them a real opportunity to practice good science teaching may not only fail to improve the system, but may in fact worsen it by frustrating the science teachers."

"During the early sixties, educational planners in the Philippines and in Thailand saw the need for improvement of the science education systems of their respective countries. One of the earliest responses, and probably the easiest to accomplish immediately, was to hold teacher upgrading workshops. In most cases the effect was either minimal or negative—the



"There is no sense . . . in putting up laboratories equipped with the very latest high-powered and expensive instrumentation when the educational system cannot adequately train people to use them . . ."

". . . Giving the science teachers better training without giving them a real opportunity to practice good science may not only fail to improve the system, but may in fact worsen it by frustrating the science teachers."

Prof. Armando Kapauan
President, Chem. Soc. of the Philippines

practise of science education did not improve. The teachers were upgraded using facilities which were way out of reach of their own institutions, using books and concepts which for the most part were not easily understood by their own students."

"The effort of upgrading the system was directed only at one point in the system, the teachers. But the problem was not in just one point—the system was the problem. No significant headway was made until a commitment was made to look into the whole system of science education, in the Philippines, with the establishment of the Science Education Center at the University of the Philippines, and in Thailand, with the establishment of a similar institution modelled after the UNESCO Pilot Project for Chemistry Teaching in Asia which was based in Chulalongkorn University in Bangkok. These centers considered not only the training of teachers but also the conceptual contents of textbooks and the language that they use, the chemicals, materials and equipment that go into experiments, the lifestyles of the students, and even such things as the economics of textbook production."

"Chemists in the schools, research laboratories, and in industry in developing countries must be made to realize that they belong to a world community of people trained using what eventually are global resources, and that this community has certain unwritten demands for a certain level of competence and depth of commitment—just as any other world community of other professionals does. This is perhaps one of the more important roles of the chemical societies in these countries."

Closely related to chemical education is the problem of *maintaining* education levels of chemistry gradutes. Discussion of this particular point was continued by Dr. Wolfgang Fritsche, General Secretary of Gesellschaft Deutscher Chemiker and Secretary of the Federation of European Chemical Societies. "There are", he noted, "other ways in which chemical societies take over the responsibility for the transfer of chemical knowledge. I am thinking here of the transfer of information by means of conferences, symposia and congresses. Such organized meetings provide our colleagues with the opportunity for the transfer of information about the progress and development in their special field of work. These meetings may be devoted to a narrow field of chemistry for specialists, but they can also cover the whole spectrum of chemistry at larger meetings where various sections participate."

"In-service training as a continuous process of learning during ones professional life is of utmost importance to anybody active in the natural science and technical disciplines. It is imperative that Chemical Societies add programmes of in-service training to

". . . Informing the layman and general public should belong to the category 'transfer of science and technology' . . . The image of chemistry and chemists among the layman can only be improved if chemists are ready to transfer . . . scientific and technological knowledge to the public. Chemical Societies and their international organizations will be the proper spokesman for that because of their neutral position between human society, government and the chemical industry."

Dr. Wolfgang Fritsche
General Secretary
Gesellschaft Deutscher Chemiker

their traditional activities, and many societies have already done so. The German Chemical Society has done some pioneering work in this area which is internationally acknowledged as setting a good example. For almost 12 years we have been able to offer about 70 in-service training courses per year covering almost all fields of chemistry and chemical technology."

"Some of you may feel that I speak more about the transfer of science and technology within one nation instead of among nations. I believe, however, that there is not a particular difference, at least not from the theoretical viewpoint. Only the practical realization is different."

"Federations within continents like the Federation of European Chemical Societies, are an additional possibility in promoting the transfer of science and technology. FECS in the now almost 10 years of its existence has proved that this works, and it has indeed contributed to the improvement of transfer among European nations. I am sure that this in future will also apply to the newly created Federation of Asian Chemical Societies."

"We should in this connection not forget IUPAC which since 1919 followed its ideals as a politically independent organization founded voluntarily by chemists on a non-commercial basis. The Union in fact promoted the transfer of science and technology by creating a common language for chemists. The Union deals with topics in the fields of pure and applied chemistry for which international agreements, standardizations and codifications are necessary. It cooperates with other international organisations devoted to chemistry, and it supports the cooperation of chemists of its member countries by promoting pure and applied chemistry in all its aspects."

"Behind all the spectacular applications of chemistry, plenty of work is performed which is less evident. Here the International Union of Pure and Applied Chemistry indeed plays a major role in the promotion of international chemistry through its very important work on international nomenclature and terminology, in setting up tables for symbols, atomic weights, purity standards and analytical methods."

"It is my firm belief that the transfer of science and technology to politicians also is a very important issue in order to influence their relevant decisions. This is a task for chemical societies, too, and they can be supported by respective agreements of their international bodies."

"I am also convinced that informing the layman and general public should belong to the category 'transfer of science and technology'. . . ! National chemical societies should exchange their experience about these activities, because the prejudices against chemistry seem to be a worldwide phenomenon these days . . . The image of chemistry and chemists among the laymen can only be improved if chemists are ready to transfer . . . scientific and technological knowledge to the public. Chemical Societies and their international organization will be the proper spokesman for that because of their neutral position between human society, government and chemical industry."

No one seriously questions the need for increased transfer of chemical knowledge and joint scientific projects, but specifically what is being done about it? In this respect, many countries look to the United States for aid, participation in joint projects, and the sharing of technology. Greater involvement in this area was emphasized by Dr. Frank Press. One goal of new bi-lateral and international exchanges, his associate stated, will be "to work jointly and share the costs on the research and development of large-scale technologies. There are a growing number of instances today, where the costs of such projects are becoming prohibitive if not shared by two or more nations, whose joint financial and research investment will eventually provide a worthwhile mutual return. We believe this will be the case, for example, in the cooperative projects we are undertaking with Japan, in the next step toward achieving fusion energy, and in advancing the liquefaction of coal".

"Along the lines of cooperative R&D with multi-

national groups, we are working with the International Energy Agency, and seeking to intensify joint energy R&D with the European Economic Community."

"There are a number of other global research projects that we continue to be engaged in, such as the Global Atmospheric Research Project. And we shall continue to cooperate in space research, as we are doing with the European Space Organization in a planned mission to examine polar regions of the sun."

"Perhaps no scientific venture that we have undertaken will result in more shared benefits than the development of earth-orbiting satellites for communications, navigation, information systems, and environmental and resources monitoring. The sharing of the technological benefits of space should grow with the advent of the Space Shuttle. The Shuttle, in addition to providing for a variety of new research projects in space, will eventually reduce the cost of placing satellites in space, and will provide the cabability of retrieving and servicing them. This . . . will make (space) technology more accessible, more economic, and more useful to many more countries."

In his address, Dr. Press emphasized the important role to be performed by the new Institute for Scientific and Technological Cooperation (ISTC). It will serve as a main link of the US government with developing countries, and as the main outlet for international development funds. Dr. Press explained that "The ISTC was recently authorized by our Congress with a first year level of funding of about $24 million plus about $66 million that will be transferred from AID (the US government program that formerly provided most assistance for international development). The Institute is scheduled to start on October 1st (1979), and we are now beginning its initial staffing and the selection of its Advisory Council."

"I think it is significant to point out," Dr. Press continued, "that...this council will also have one-third of its members from the developing countries. And the director of the Institute will be required to consult with the Council before making decisions on the Institutes major activities. This will assure the necessary collaborative relationship with the developing world, by providing for foreign member input at the policy-making level. In addition, the legislation that established the Institute provides for Fellows from developing countries who will serve on the Institute's staff for a period of up to two years. Twenty fellowships are authorized."

". . . We see the ISTC as the principal R&D organization of our foreign assistance program. It will be separate from AID and the U.S. bilateral program. It will be organized in a way that it can sustain long-term attacks on critical development problems requiring research and experimentation."

"Another focus of the Institute will be on problems of poverty and the meeting of basic human needs, which in many respects will be the dominant emphasis of its programs. But the Institute will also be dealing with problems of shared global concern—problems involving energy needs, environmental protection and the conversion and use of natural resources. Even problems of food and health, while they may differ in many ways in the developing and industrialized nations, have some common elements."

"Finally, let me reemphasize the point I made earlier; that this new Institute will be . . one involving not merely the cooperation of governments, but of scientists, technologists, and experts and people in all fields at all levels."

As far as direct *personal* contact and exchange of ideas between chemists, one of the most effective means is probably exchange programs, in which chemists from different countries, cultures and backgrounds spend a period of time in each other's country. Yet, "at present there are relatively few exchanges of chemists at the international level in comparison with those in other disciplines (education, social science, medicine, etc.)", notes Prof. Kamchorn Manunapichu, Chairman of the Chemistry Section of the Science Society of Thailand, and President of the new Federation of Asian Chemical Societies.

"If we take the work 'exchange' to mean. . . exchange in the same field and with equally qualified chemists. . .(then) there is hardly any support along this line from grants. If however, an exchange covers only the improvement of knowledge and experience of chemists in one organization with the help of guest chemists) from another organization or country, then such support is given by many organizations, governments or foundations... we can categorize

"At present there are relatively few exchanges of chemists at the international level in comparison with . . . other disciplines", notes Prof. Kamchorn Manunapichu of Thailand. He proposes an international programme to pool the funding available for exchange programmes, and provide for study tours, training or foreign advisors, depending on the needs within the recipient country.

presently available grants for exhange of chemists as follows: (Research) grants from an institution . . . usually require a certain level of knowledge and expertise . . . Examples are salaries for co-investigators which are a part of research grants awarded to principal investigators by various research organizations. Offers of such grants are frequently advertised in established journals, e.g. *Science*. These grants are available only in developed countries. This is not an exchange program in the strict sense, but is beneficial to chemist grantees from developing countries. In universities such grants are in the form of assistantships and postdoctoral fellowships, which are offered to chemists in the same country as well as those from abroad."

"Grants from organizations are prevalent in developing countries, although very few are for chemists. In some cases chemist applicants may have to choose projects which are closely related with chemistry, and then to choose their words in the application forms very carefully in order to be awarded such grants. These grants are mostly for scientists from developing countries to seek further studies, training or new experience . . ."

"Organizations which award grants are many, some of which should be mentioned here, e.g. the United Nations Educational, Scientific and Cultural Organization (UNESCO). This organization provides programs to help scientists all over the world. Unfortunately its Programme of Natural Sciences and their Application to Development does not embrace many projects concerning chemistry."

UNESCO has helped organize Regional Networks in Chemistry and sponsored seminars, workshops, conferences and exchanges of chemists within each region."

"The International Foundation of Science (IFS) provides promising young scientists and technologists from developing countries with grants for their research and other appropriate projects."

"The Norweigan Agency for International Development (NORAD) awards fellowships to highly qualified candidates from developing countries who seek the opportunity of doing research or training in Norway."

"The International Development Research Centre (IDRC) aims to initiate, encourage, support and conduct research into the problems of the developing regions of the world. . . . At present IDRC provides research funds only in agriculture, food and nutrition sciences, information sciences, population and health sciences, social sciences, and human resources, but from its objects chemistry can be included in this list. The Centre also gives research associate awards to professionals at the mid-career level to take a sabbatical year to undertake training, research or investigation."

"The Japan Society for the Promotion of Science (ISPS) has many major activities. JSPS is sponsoring two types of programmes to help Japanese scientists invite their foreign colleagues to Japan for cooperative research and other academic purposes. There are short-term fellowships for senior scientists, and long-term fellowships for senior or junior scientists to undertake research work with Japanese scientists."

To promote the exchange of chemists, Prof. Manunapichu proposed that an international programme be started for this purpose. Initially, it would be a pilot programme involving a few countries. Grants available from all over the world would be pooled together, and provided for study tours, education, training or acquisition of experts—depending on the needs of organizations within the recipient country.

International Fellowships for Study and Training in Chemistry

Country	Name of Fellowships	Language	Duration (months)
Australia	Graduate courses for Overseas Students	English	9(Mar.-Dec.)
Belgium	La Chimie Physique Moleculaire	French	9(Oct.-June)
Czechoslovakia	Macromolecular Chemistry	English	10(Sept.-June)
	Modern Methods of Anal.Chem.	English	10(Sept.-June)
Germany	Research and Education in Chemical Engineering and Physical Chemistry	German	15(May-July)
France	Postgraduate Training Courses	French	9(Oct.-July)
Japan	International Postgraduate Univ. Course in Chem. and Chem. Engineering	English	12(Oct.-Sept.)
Sweden	International Seminars in Physics and Chemistry	English	10(Sept.-July)

All fellowships listed here are given annually, except for Czechoslovak fellowships (which are biannual). Information presented by Prof. Kamchorn Manunapichum, President of the Federation of Asian Chemical Societies.

Emphasis of energy research varies between nations

Virtually no country remains untouched by the global impact of the "energy crisis", yet the response of different countries varies widely. This is reflected in the research and development programs aimed at developing alternative supplies of energy and hydrocarbons. Many countries are undertaking research in closely-related areas and are participating in cooperative joint research efforts. On the other hand, the emphasis placed on each type of alternative energy varies with national climate, geography, resources and culture. Considerable differences in outlook may be found, for example, in France, Canada and Japan—countries widely separated on three continents that face very different problems. Yet, the future of each is intimately tied to the development of new technologies for alternative energy supplies. It was on this topic that chemical society presidents of these countries focussed their attention at the 7th International Meeting of Chemical Society Presidents.

The role that chemical research will have in providing future energy needs was a main theme discussed by Prof. Fernand Gallais, President of the Société Chimique de France. He proceeded to the meeting of chemical society presidents (held in Washington D.C., USA) following the IUPAC General Assembly in Switzerland, where he participated in the Inorganic Chemistry Division meetings. His address to fellow chemical society presidents touched on several areas of concern to all scientists.

"Now, for all of us, chemists from the whole world, the question is what part can chemistry play in the improvement of the critical situation caused by the lack of oil?"

"If we leave aside the special but important sector of nuclear chemistry, the best chemistry could do would be to provide new synthetic fuels. If methane and ethanol may be classified as such is dubious, but chemistry is anyhow involved in their large scale production from biomass, and in the materials science research required to meet their corrosive properties. The treatment of bituminous schists or sands also stands on the border line (to be called new synthetic fuels) but the gasification of coal, the Fischer-Tropsch and other similar processes (for coal liquefaction) will certainly contribute efficiently in the near future to the replacement of part of the natural hydrocarbons. And it should be mentioned that chemistry will be a major help to improve oil recovery in a way which will increase natural resources."

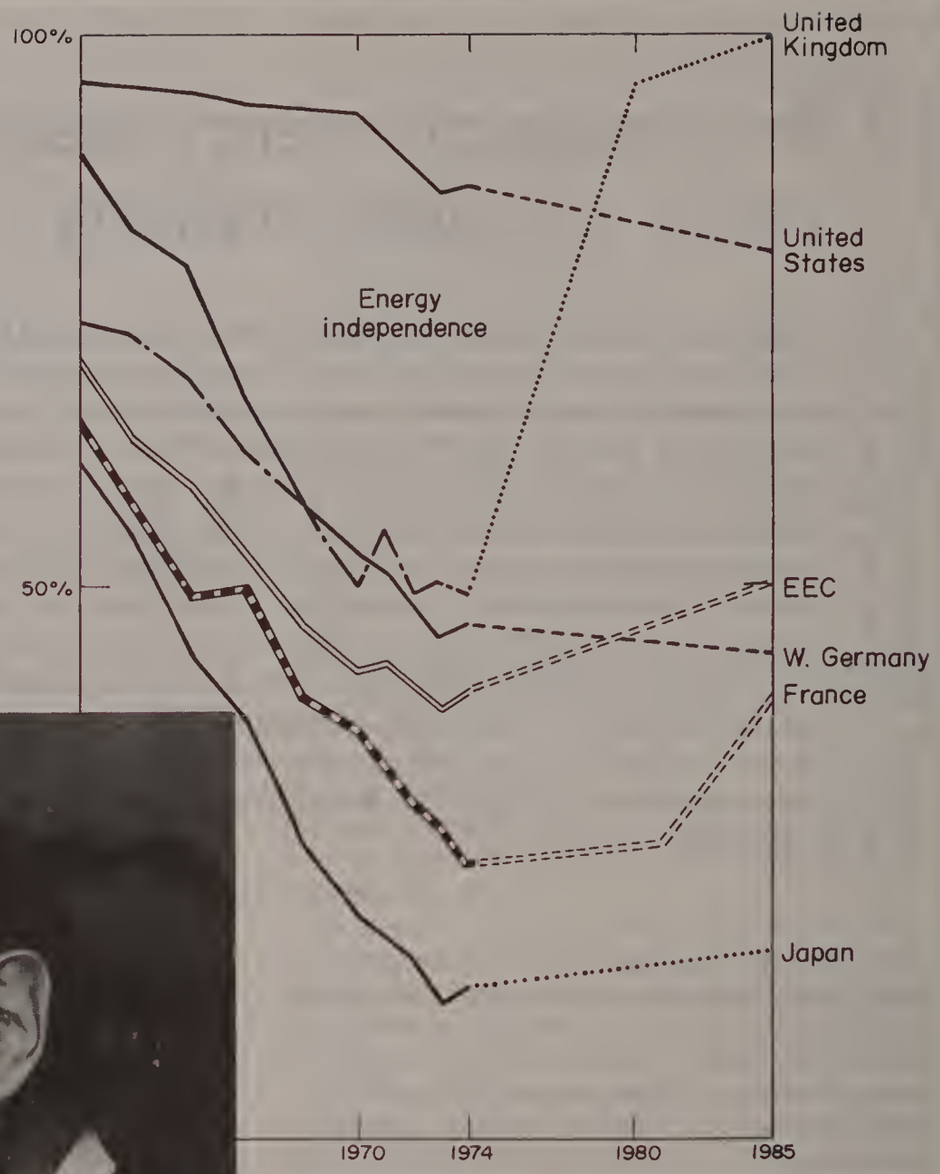
"But chemistry is also called to help store energy. May I report that the French National Center for Scientific Research and the corresponding Swedish Organisation have launched together a research program on the topic. The main items are electric cells and battery improvements, solid electrolytes and new electrodes, electrocatalysis, photo- and photoelectric synthesis, metallic hydrides, and also reversible reactions which could be used for solar energy storage, either between 25 and 120°C for house air conditioning or between 200 and 500°C for thermodynamic power stations."

"But the most important contribution chemistry will make to the evolution of the energy problem is probably still unknown, and the interest which has been aroused by the discovery of hydrogen production by the photodecomposition of water is probably a good example of the great things we may hope for."

Prof. Gallais dealt specifically with the unique energy resource and technological position of France, and how it could best be exploited to provide indigenous needs. "Let us now have a look at the prospective energy needs in France up to eve of the 21st century. Even assuming that the annual increase will be lower after 1985 than it has been since 1975 (3.8%), the energy needs in the year 2000 will have been multiplied by a factor of 2 in twenty five years! Taking into account all energy sources available, including all new—or better renewable ones—it appears that the only hope to attain an equilibrium situation is to develop nuclear power on a very large scale."

"In the year 2000 we should possess some 50 - 80 stations of 1000 or perhaps 1500 MW. On a technical basis this is a thing that we are quite able to achieve and it appears extremely desirable if one has in mind that we have practically no oil, and we are the only EEC country to possess appreciable reserves of uranium ores. We are now extracting nearly half the 4000 tonnes we use annually, but we could be self-sufficient in that field until the 1990's. This means that our uranium reserves are equivalent to a third of the oil expected to come from the North Sea. But if instead of the PWR reactors, we turn to breeders with which we are already familiar and which need 50 or 80 times less uranium, then our nuclear fuel

The United Kingdom will be the only energy-independent country in Western Europe in 1985—a result stated by Prof. Gallais, and backed by this table showing the past, present and projected ability of each country to produce its own energy requirements (provided by the French Ministry of Industry).



"Taking into account all energy sources available...it appears that the only hope (for France) to attain an equilibrium situation is to develop nuclear power on a very large scale."

Prof. Fernand Gallais
President, Chemical Society of France

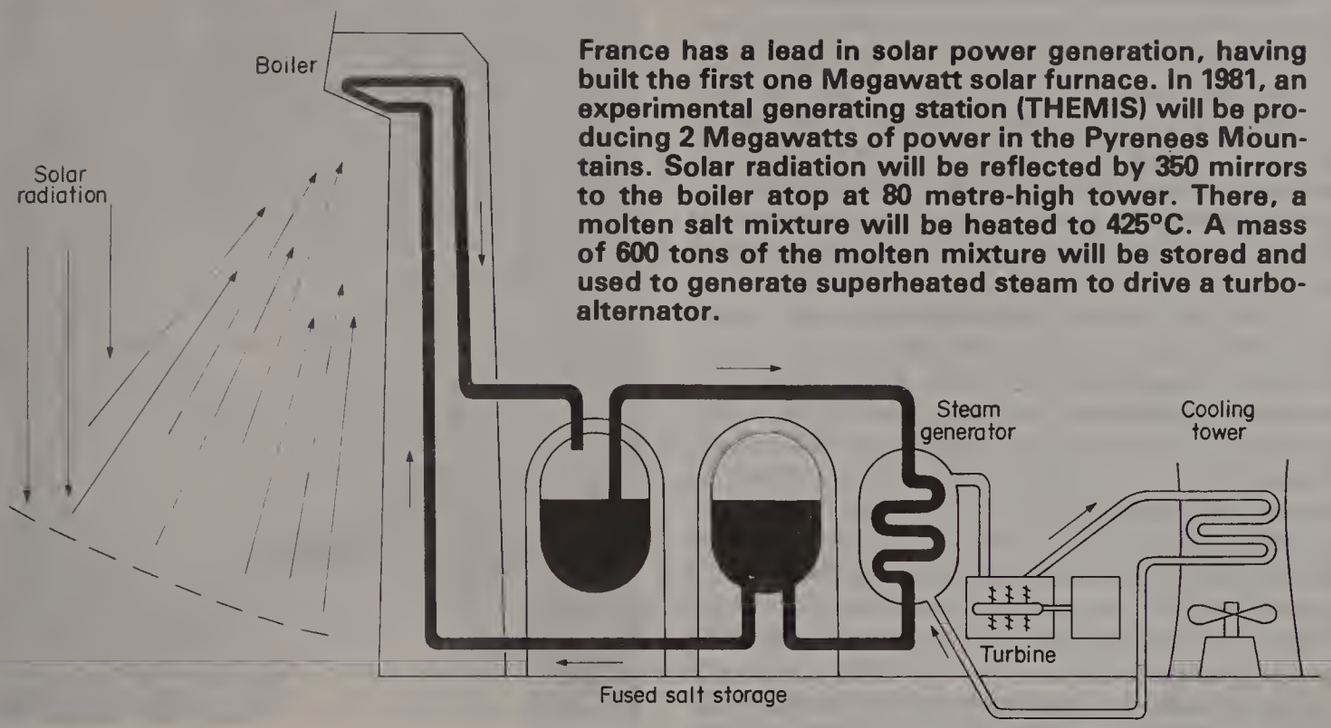
reserves would be equivalent to three times the Saudi Arabian oil ones. Moreover, we are concentrating ourselves natural uranium up to the necessary 3 - 3.5% Uranium-235. But various reasons, political and ecological in nature, have already succeeded in hampering the launching of our last nuclear power stations."

"Still, even if the 2000 figure for nuclear energy could be attained, the situation of France should remain uncomfortable, its dependency rate (on foreign energy sources), which is now more thant 70%, remaining equal to 55%. It must be realized that this is not unusual in Europe, but this, of course, doesn't make things any better for us. . ."

"We have had a good start in the field of thermodynamic conversion of solar energy as the French National Center for Scientific Research had built in the 1960's a 1000 kilowatt solar furnace which has been the only one existing for some years. It was originally designed and built for chemical purposes, but it has now been turned into a small experimental power station which has delivered the first "solar kilowatts" in 1976. A real power station must be of course rather different, as it is quite another goal to heat a few tonnes of calorific fluid to a temperature of 400 - 500°C (to produce power) than to raise the temperature of a few kilograms of a refractory material over 3000°C (to bring about chemical reactions). Still, the knowledge acquired in the realisation of a large field of mirrors astrained to follow the sun in its course and to focalise its radiation on a fixed receptor has been extremely useful to our engineers."

"The plan is now to build an experimental station of 2 MW. Known under the name of THEMIS it will be located in the south of the country, near the Pyrenees Mountains and close to the first solar furnace. It should be operative in 1981."

"The radiation reflected by 350 mirrors of 50 m^2



France has a lead in solar power generation, having built the first one Megawatt solar furnace. In 1981, an experimental generating station (THEMIS) will be producing 2 Megawatts of power in the Pyrenees Mountains. Solar radiation will be reflected by 350 mirrors to the boiler atop at 80 metre-high tower. There, a molten salt mixture will be heated to 425°C. A mass of 600 tons of the molten mixture will be stored and used to generate superheated steam to drive a turbo-alternator.

each will be focalised on a boiler . . . filled with fused salts mixture heated up to 450°C. A mass of 600 tonnes (of fused salts) circulating between two tanks of 400 m^3 should allow six hours of sunshine to be stored, the storage temperature being 425°C. It would generate superheated water vapor which, in turn, would move a turbo-alternator before being air-cooled at 54°C."

"The ground surface occupied by the mirrors being 5 hectares, the radiation power received under the best conditions is approximately 13 MW, so the overall rate of conversion would be of the order of 16%. The limiting factor is, of course, the thermodynamic cycle. The climatic characteristics of the site are such that the energy which THEMIS should produce each year is expected to equal 3500 MWh. Quite naturally, in a tropical region, the figure might be twice as large as that. . . It will be extremely interesting to see how the THEMIS project stands in 1981 against the Sicilian EEC project of 1MW and against the USA Pilot Plant of 10 MW which would be operative in California at that time."

The variation of recoverable solar energy, referred to by Prof. Gallais, points to a more general point: technology and methods need to be modified to suit local climate and environment. Perhaps nowhere is this more evident than in Canada. It was this point, and the distinctly different Canadian conditions than are found in Europe, that was highlighted by Dr. Louis Renzoni, President of the Chemical Institute of Canada. He too addressed the meeting of chemical society presidents after attending the IUPAC General Assembly.

"Canada", he said, "seems to be perceived as . . . bountifully endowed with energy resources . . . (and with) a high *per capita* energy consumption. These views are misleading. I draw your attention to the severity of the Canadian climate and to the large size of Canada, the largest country in the Western Hemisphere. It stretches some 3000 miles from Atlantic to Pacific, and from the 49th parallel to the deep Arctic. And yet this vast land is only 11% occupied by permanent residences. One can almost picture Canada as a strip of land 3000 miles long by about 400 miles wide. Most of the industrial activity is conducted in the area. The regions to the north are inhospitable and only sparsely populated. Yet, it is this vast region which contains the energy and mineral resources. Their exploitation is difficult, requiring the . . . costly, energy intensive, transport of materials over long distances."

"In these remote locations, turnover of personnel presents an almost impossible obstacle. In the producing locations such as Thompson, Man. (Nickel), Yellowknife, N.W.T. (Gold), Granisle, B.C. (Copper, Oil), winter comes in early October and leaves in late May. Temperatures drop to minus 40 or 50 for weeks on end and demands on fuel are consequently high."

"From the standpoint of liquid fossil fuel reserves, the current firm outlook is not so rosy. Canada's energy needs are met by oil 46%, natural gas 20%, coal 8%, uranium 7% and hydro-electric power 20%. As nuclear power development increases, it is estimated that not more than 50% of primary energy will be generated from oil and natural gas."

"Current production of liquid hydrocarbons is about 1.6 million barrels per day. Reserves are estimated at 8 billion barrels for an estimated life of only 14 years excluding reserves in the tar sands. This is not an encouraging outlook and it is one which prompted the development of the tar sands in Northern Alberta. Capital cost of the Syncrude development there was some $4 billion for a system having a capacity of 125,000 barrels of crude oil per day. . . Currently, Imperial Oil is considering development of tar sands occuring at greater depth at Cold Lake, Alberta. The venture is estimated at $7 billion."

"Canada's proven reserves of natural gas indicate a life of about 25 years. There are numerous reports of intensive and extensive exploratory activity for oil and natural gas in the Beaufort Sea, the MacKenzie Valley, the Artic Islands and the offshore reaches of Newfoundland. Optimistic reports are circulating. Whether these are real or mainly a gleam in the investor's eye remain to be seen—but hope there is!"

"Coal reserves in Canada present a much happier outlook. Currently, Canada's coal production runs at about 30 million tons per year which may double in the next ten years. Even at the higher rate, coal reserves are estimated conservatively at 500 years. Most of Canadian coal is relatively low in sulfur—not more than 1.5%. With respect to research, Canada is pursuing an active campaign aimed at conversion of coal into liquid and gaseous hydrocarbons."

"Canadian uranium production was at the rate of about 5000 tons per year in 1977. At that rate, a conservative estimate of reserves indicated a 20 year life. However, exploration is showing promise of widespread deposits of high-grade material in Northern Saskatchewan. At the moment, the outlook is obscure but promising."

"The nuclear power industry of the world is already large with some 200 operating reactors and about 350 under some stage of development. In total, they represent about 30% of the world's electrical power production."

"In Canada, the fraction is nearly 8% and in the province of Ontario, 27%. The country has 7 reactors and 15 under construction or in the planning stage."

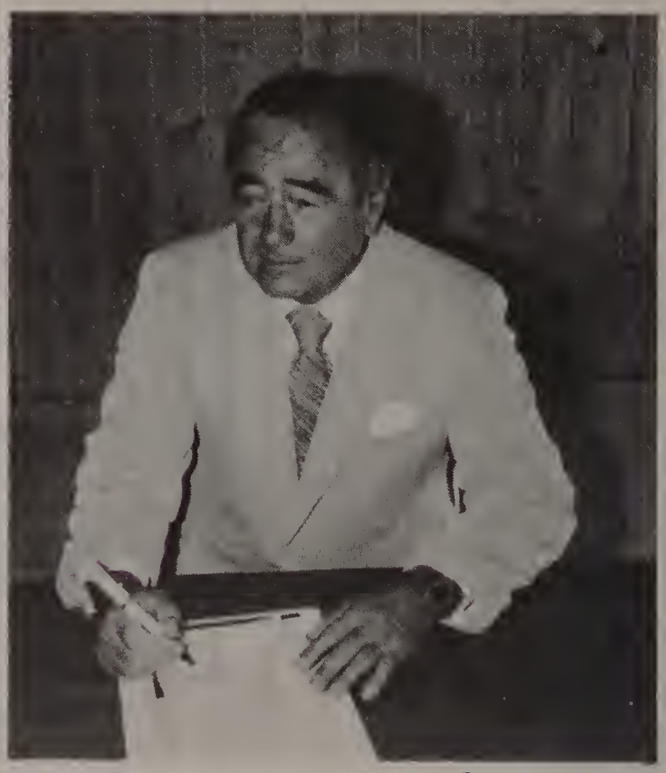
"Canada chose, in the early 1950's, to base its nuclear energy program on the natural uranium—heavy water reactor. Recovery and recycle of plutonium was postponed for the future . . . When natural uranium is used, only a small fraction of the fuel is utilized. Plutonium is produced and can be recovered for recycle with natural uranium to double the available energy. With thorium, the gain in energy from recycle is more dramatic. Uranium-233 is produced in the fuel (from Neutron irradiation of thorium) and this constitutes the most effective fissile material for a heavy water reactor. However, the numerous vexing problems involved in the development of the thorium fuel cycle seem to place it several decades away."

"Canada is participating in the International Nuclear Fuel Cycle Evaluation initiated by President Carter last year. Until the outcome of the study is clear, the Canadian government will continue to confine research on fuel recycle to the laboratory."

"Canada is studying other important aspects of energy generation, among which are: (1) Direct conversion of solar energy, (2) Use of biomass, including development of fast growing hybrid trees, (3) The utilization of wind and wave energy, and (4) Examination of hydrothermal energy from wells in the far west."

"Canada, I think, would like to participate in the development of fusion energy. We know that this really requires the large resources of the super nations. However, it may be possible for Canada to participate, as it did in the Manhattan project where it could apply some of the expertise available to problems of limited scope."

The energy strategy of Canada takes into account its substantial remaining reserves of hydrocarbons, enormous land area and severe climate. A nearly opposite situation confronts those who formulate energy management programs in Japan. By contrast, Japan has extremely limited energy resources. Its small land area serves as both a disadvantage (for growing biomass) and as an advantage (allowing efficient fuel utilization for transportation systems). The Japanese options for developing alternative energy systems were summarized by Dr. Yasuhide Yukawa, President of the Chemical Society of Japan.



"One can almost picture Canada as a strip of land 3000 miles long by about 400 miles wide. . . . The regions to the north are inhospitable and only sparsely populated. Yet, it is this vast region which contains the energy and mineral resources. . . . Temperatures drop to -40 or -50°C for weeks on end and demands on fuel are consequently high."

President Louis Renzoni
Chemical Institute of Canada

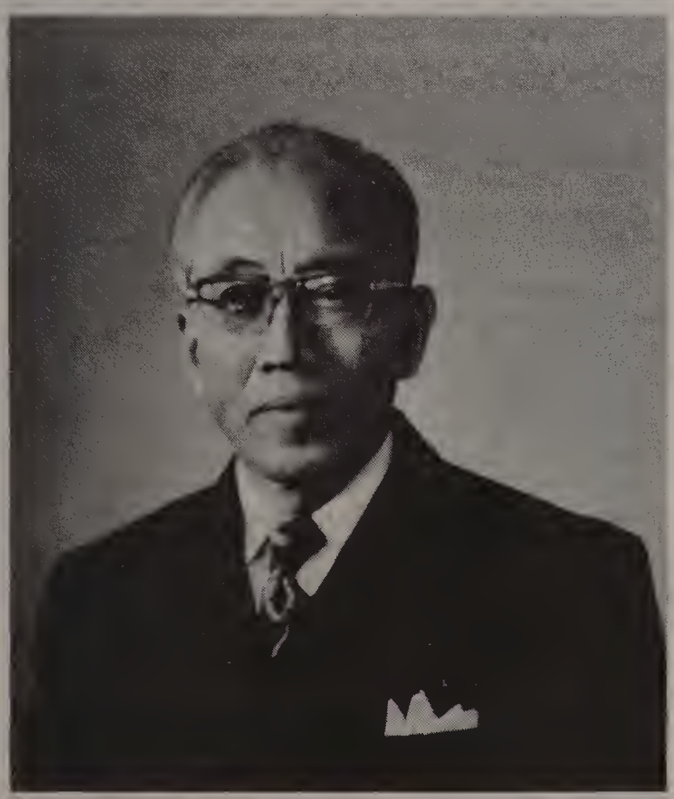
Dr. Yukawa noted that "The so-called energy crisis encompasses short-term localized shortages of oil products on one hand, and long-term global shortages of energy on the other hand. The solution to the short-term problems comes mostly from political and economic handling. The solution to the long-term problems, however, must depend upon technological progress."

"Scarcity of energy reserves, especially of fossil fuel reserves, is characteristic of the energy situation in Japan. Ninety percent of the Japanese energy requirement is supplied by imported resources. . . . What is worse, Japan cannot expect domestic exploitation of alternate fossil fuel resources. In the future, Japan will have to utilize all the possible energy resources to meet its requirements."

"Nuclear energy is the most readily accessible alternate energy and currently generates nearly 10% of Japanese electric power. In view of environmental considerations and the national sentiment, however, it seems very difficult for the Japanese people to conceive that most alternate energy depends upon

nuclear energy. As I mentioned above, Japan does not have alternate energy resources such as coal, natural gas, oil sands, or oil shale. Our major concern, therefore, is with security of reliable energy resources."

"In discussing the role of chemistry in energy research, first I would like to list present activities for exploitation of alternate energy in Japan. As to the utilization of non-petroleum fossil fuels, I can mention coal liquefaction and gasification. In coal liquefaction, three solvent processes and a direct hydrogenation process are being investigated. The SRC II process has been under joint research with the United States and West Germany. To develop the C-SRC process, a test plant is being established at Victoria coal field in Australia. The third process, a solvolysis process peculiar to Japan, makes use of petroleum as the base solvent. Besides these processes, a direct hydrogenation process is under investigation. In coal gasification research, interesting results are now produced at Tohoku University in the study of non-aqueous solvent treatment, that is, treatment with liquid SO_2 or liquid NH_3."



"The so-called energy crisis encompasses short-term localized shortages of oil products on one hand, and long-term global shortages of energy on the other hand. The solution to the short-term problems comes mostly from political and economic handling. The solution to the long-term problems, however, must depend upon technological progress."

Dr. Yasuhide Yukawa
President, Chemical Society of Japan

"Hydrogen is regarded as a uniquely clean fuel . . . (and as) an essential component in utilization of non-petroleum carbon sources. Several thermochemical hydrogen cycles have been proposed. In Japan, Tokyo Industrial Research Institute has conducted research into magnesium iodide, Tokyo University into lime and ferrous bromide, and Kyushu University into antimony iodide and lime. For photodecomposition cycle, Yokohama National University has pursued investigation of a ferrous sulfate and iodine system. These are long-range research projects."

"Biomass has become the object of attention as biological energy resource. In Japan, which is geographically narrow, it has to compete with food production, thus limiting this field of study to agriculture and food wastes."

"The projects so far mentioned are developmental in nature. now I would like to mention fundamental research with regard to energy. . . . In research of chemical conversion and storage of energy, formation of high-energy chemicals is under investigation. The object is to convert and store light energy as chemical energy. Some examples are (the conversion of) Caged dienes to Cyclobutanes, Alkenyl imides to Imide oxetanes, Naphthalenes to Naphthovalenes, Silacyclopentadienes to Dimers, and Nitro compounds to Nitrito compounds. . . . (Another) point is the investigation of solar energy conversion and storage with photochemical cells. . . . As semiconductors, amorphous silicon wafer has been exploited and ultra-thin polymeric wafers are being investigated as photoenergy conversion electrodes. Photochemistry such as photosynthesis, together with nuclear fusion technology, are the subject of joint research of the United States and Japan."

"It is also important to do fundamental research on the exploitation of . . . materials with ultra-high (and) ultra-low temperature resistance, high corrosion resistance or superconductance. . . . (These are) essential for the development of nuclear fusion reactors, geothermal and ocean energy utilization."

"Before closing my remarks, I would like to touch upon energy conservation. . . . Personal *per capita* consumption of energy in Japan is about ⅓ of the United States and ½ - ⅔ of European countries. One reason for this is small living quarters . . . another is highly developed transportation systems made possible by the high population density. In addition, the Japanese people are generally more conscious about conservation of resources because of their scarcity."

"Solar water heating has been greatly used in Japan. More than 200,000 small units made of plastic are sold annually and a few million households have these units for hot water supply. For more than 20 years, my family has made use of this solar system. I can tell by experience that the initial investment can be recovered easily in 3 - 5 years."

"I believe the conservation of energy is Japan will be most effectively accomplished by the increased efficiency in industrial usage of energy. This can be done by technological development. Research is being done on MHD power generation and high efficiency gas turbines."

"In conclusion, the solution to energy problems in Japan is dependent upon . . . international cooperation to obtain energy resources in exchange for new technologies."

COURSES

ADVANCED INORGANIC CHEMISTRY

5 Aug. - 31 Oct. Post-graduate course in Techniques in Advanced Inorganic Chemistry specially designed for students from developing countries who are presently employed in tertiary teaching or research institutes. To be held at University College, Dublin (Ireland).

Course Contents: The course includes a formal 5 week period of lectures and laboratory work, followed by research work in a project of the university staff, dealing with Organometallic, Coordination or Theoretical Inorganic Chemistry.

The language of instruction will be English. Students applying for this course will be expected to have a Master's degree. Applications explaining the candidate's background, experience and names of referees should be made through the UNESCO Commission of their respective countries. Some fellowships to cover expenses are available from the Irish government, UNESCO, and the EEC.

LASERS

3 Feb. - 3 Apr. 1981. Winter College on Lasers in Atomic and Molecular Physics. To be held in Miramare-Trieste, Italy. A two week introductory sessions will treat the basic theory of atomic and molecular spectroscopy; elements of group theory and angular momentum techniques; and selected topics in quantum mechanics. The remainder of the course will be divided into 2 parts. The first dealing with *Laser Principles and Techniques in Atomic and Molecular Spectroscopy*, is intended for theoretical and experimental physicists. The second part of the course concerns *Lasers in Chemistry and Biology* and is especially of interest to chemists and biologists.

The course is sponsored by the International Centre for Theoretical Physics, the Int. Atomic Energy Agency, and UNESCO. The course will be conducted in English.

There is no tuition fee, but travel and subsistence expenses will generally be borne by the home institution. Applications for the course will be accepted up to 30 September 1980.

The College is open to research workers from all countries that are members of the United Nations, IAEA or UNESCO. Its main purpose is to help researchers from developing countries, but it is also open to graduate students and post-doctoral scientists from advanced countries. A knowledge of basic quantum physics is necessary.

Further information may be obtained from the International Centre for Theoretic Physics, P.O. Box 586, I-34100, Trieste, Italy.

RECENT REPORTS

Electrode reaction orders, transfer coefficients and rate constants. Amplification of definitions and recommendations for publication of parameters. Prepared by Roger Parsons. *Pure and Appl. Chem.*, 52. (Jan. 1980) pp. 233.

Analytical Biochemistry of Nickel. *Pure & Appl. Chem.*, 52. (Feb. 1980)

Nitrosamines and Pesticides: a special report on the occurrence of nitrosamines as terminal residues resulting from agricultural use of certain pesticides. Prepared by P. C. Kearney. *Pure & Appl. Chem.*, 52 (Feb. 1980) pp. 501-526.

ASIAN CHEMISTRY WORKSHOPS

1-2 August. Regional Symposium on development and application of naturally occurring drugs. Tokyo, Japan.

Late August. Extraction, separation and purification techniques. Seuol, Korea.

8-12 September. Regional workshop on the production and utilization of essential oils. Bangkok, Thailand.

15-19 September. Fourth Asian Symposium on medicinal plants and spices. Bangkok, Thailand.

(Further information on these Asian chemistry workshops may be obtained from the Division of Scientific Research and Higher Education, UNESCO, Paris 75007, France)

FLOW IN THE OCEANS, ATMOSPHERE AND DESERTS

30 Sept. - 28 Nov. 1980. Autumn Course on the Physics of Flow in the Oceans, Atmosphere and Deserts. To be held in Miramare-Trieste, Italy. This integrated course will consist of lectures on *Geophysical Flow Dynamics,* followed by a Topical Meeting on *Physics of Waterlogging and Salinity,* a conference on *Circulation and Transport in the Mediterranean,* and a workshop on the *Physics of Desertification.*

The course is sponsored by the International Centre for Theoretical Physics, and co-sponsored by the Int. Union of Geodesy and Geophysics and the Regional Government of Fruili-Venezia. English will be the language of the course.

There is no tuition fee. Applications for the course must be received by 30 June 1980. The course, conferences and workshop are open to scholars from all countries that are members of the United Nations, IAEA or UNESCO.

Further information may be obtained from the International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste, Italy.

NOMENCLATURE INDEX

Listed here are rules for naming, symbolizing and representing chemical compounds, formulas and data published by IUPAC in recent years. Nomenclature rules are developed by IUPAC Commissions and initially published in provisional form. Comments are sought during the following period, and changes may be incorporated before the rules are approved for publication in definitive form.

ACTIVITIES

Definition of Activities and Related Quantities. Appendix 1 of "Manual of Symbols and Terminology for Physicochemical Quantities and Units", 1979 Edition. Available from Pergamon Press.

AMINO ACIDS AND DERIVATIVES

Nomenclature of Amino Acids (Provisional Nomenclature Appendix No. 46, September 1975)

Symbols for Amino Acid Derivatives and Peptides (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 315-331).

see: proteins & peptides

ANALYTICAL CHEMISTRY

Compendium of Analytical Nomenclature, Definitive Rules 1977. Published as a book by Pergamon Press, Oxford. 1978.

Guide to Trivial Names and Synonyms (for Substances used in Analytical Chemistry) *Pure & Appl. Chem.*, No. 4, 1978, p. 339).

see also: Microchemical Analysis, Spectrochemical Analysis, Chemical Analysis.

ATOMIC ABSORPTION / EMISSION

See: Spectrochemical Analysis.

BIOCHEMISTRY

Recommendations for Measurement and Presentation of Biochemical Equilibrium Data (Provisional Nomenclature Appendix No. 61, July 1977, *Info. Bull.*).

see: Clinical Chemistry, Phosphorous - containing compounds of Biochemical Importance, Nucleic Acids, Proteins, Enzymes, Vitamins, Lipids, Carbohydrates.

BORON COMPOUNDS:

Nomenclature of Inorganic Boron Compounds (*Pure & Appl. Chem.*, Vol. 30, Nos. 3-4, 1972, pp. 681-710).

CALORIMETRY

See: Thermodynamics.

CARBOHYDRATES

Carbohydrates Nomenclature (Tentative Nomenclature Appendix No. 7, September 1970).

CARBON

International cooperation on characterization and terminology of carbon and graphite. (*Pure & Appl. Chem.*, Vol. 51, No. 7, 1979, pp. 1561-1574).

CAROTENOIDS

Nomenclature of Carotenoids (*Pure & Appl. Chem.*, Vol. 41, No. 3, 1975, pp. 405-431).

CATALYSIS

Heterogenous Catalysis—see: Surface Chemistry.

CHEMICAL ANALYSIS

Recommendations for presentation of data on complexiimetric indicators. 1. General (*Pure & Appl. Chem.*, Vol. 51, No. 6, 1979, pp. 1357-1336).

Colorimetric and fluorimetric determination of aldehydes and ketones (*Pure & Appl. Chem.*, Vol. 51, No. 8, 1979, pp. 1803-1814).

Colorimetric and Fluorimetric determination of steroids. (*Pure & Appl. Chem.*, Vol. 51, No. 10, 1979, pp. 2157)

Recommendations for Publication of Papers on Precipitation Methods of Gravimetric Analysis (Provisional Nomenclature Appendix No. 69, December 1977, *Info. Bull.*).

Recommended Nomenclature for Automatic Analysis (*Pure & Appl. Chem.*, Vol. 21, No. 4, 1970, pp. 527-531).

See: Spectrochemical Analysis, Electrochemistry (for Electroanalytical Techniques), Microchemical Analysis, Equilibria.

CHROMATOGRAPHY

Recommendations on Nomenclature for Chromatography (*Pure & Appl. Chem.*, Vol. 37, No. 4, 1974, pp. 445-462).

CLINICAL CHEMISTRY

Quantities and Units in Clinical Chemistry (*Pure & Appl. Chem.*, Vol. 51, No. 12, 1979, p. 2451-2480).

List of Quantities in Clinical Chemistry (*Pure & Appl. Chem.*, Vol. 51, No. 12, 1979, p. 2481-2502).

Characteristics and Attributes of Instruments intended for Automated Analysis in Clinical Chemistry (*Info. Bull.*, No. 3, 1978).

Quantities and Units in Clinical Chemistry - Optical Spectroscopy: Part 1 (Theoretical Outline and General Quantities) (*Info. Bull.*, No. 3, 1978).

COLLOIDS

See: Surface Chemistry, Micelles.

CORRINOIDS

Nomenclature of Corrinoids (*Pure & Appl. Chem.*, Vol. 48, No. 4, 1976, pp. 495-502).

CYCLITOLS

Nomenclature of Cyclitols (*Pure & Appl. Chem.*, Vol. 37, Nos. 1-2 1974, pp. 283-297).

ELECTROCHEMISTRY

Recommended terms, symbols, and definitions for electroanaiytical chemistry. (*Pure & Appl. Chem.*, Vol. 51, No. 5, 1979, pp. 1159).

Selectivity coefficients of ion-selective electrodes. (*Pure & Appl. Chem.*, Vol. 51, No. 9, 1979, pp. 1913-1980).

Recommendations for Pubiishing Manuscripts on Ion-Selective Eiectrodes (*Info. Bull.* No. 1, 1978, pp. 69-74).

Standard Potential of the siiver-silver Chloride Electrode (*Pure & Appl. Chem.*, No. 11/12, 1978, p. 1701).

Proposed Nomenclature for Transport Phenomena in Electroiytic Systems (Provisional Nomenclature Appendix No. 59, July 1977).

Eiectrode Reaction Orders, Transfer Coefficients and Rate Constants—Amplification of Definitions and Recommendations for Pubiication of Parameters (Provisionai Nomenciature Appendix No. 60, Juiy 1977).

Classification and Nomenciature of Eiectroanaiyticai Techniques (*Pure & Appl. Chem.*, Voi. 45, No. 2, 1976, pp. 81-97).

Status of Faraday Constant as an Analyticai Standard (*Pure & Appl. Chem.*, vol. 45, No. 2, 1976, pp. 125-130).

Recommendations for Sign Conventions and Piotting of Electrochemical Data (*Pure & Appl. Chem.*, Vol. 45, No. 2, 1976, pp. 131-134).

Recommendations for Nomenclature of Ion-Selective Eiectrodes (*Pure & Appl. Chem.*, Voi. 48, No. 1, 1976, pp. 127-132).

Electrochemical Nomenclature (*Pure & Appl. Chem.*, Vol. 37, No. 4, 1974, pp. 499-516).

ELECTRON SPECTROSCOPY

Nomenciature and Spectral Presentation in Electron Spectroscopy Resuiting from Excitation by Photons (*Pure & Appl. Chem.*, Vol. 45, Nos. 3-4, 1976, pp. 221-224).

ELEMENTS

Recommendations for the Name of Elements of Atomic Numbers Greater than 100 (*Pure & Appl. Chem.*, Voi. 51, No. 2, 1979, pp. 381).

Atomic Weights of the Elements, 1977 (*Pure & Appl. Chem.*, Voi. 51., No. 2, 1979).

ENZYMES

Nomenciature of Muitiple Forms of Enzymes (Provisional Nomenciature Appendix No. 68, December 1977).

Enzyme Nomenclature (Book, 443, pages; casebound and soft-cover editions Elsevier, POB, 1270, Amsterdam, Netheriands).

EQUILIBRIA

Recommendations for presentation of data on compleximetric indicators 1. General. (*Pure & Appl. Chem.*, Voi. 51, No. 6, 1979, pp. 1357-1366).

Proposed Symbois for Metal Compiex Mixed Ligand Equiiibria (*Info. Bull.*, No. 3, 1978).

FLUID FLOW

Selected definitions, terminoiogy and symbols for rheoiogical properties. (Manual of Symbois and terminoiogy for physicochemicai quantities and units. Appendix II.) (*Pure & Appl. Chem.*, Vol. 51, No. 5, 1979, pp. 1213).

FOOD

A survey of methods for the determination of non-voiatiie nitrosamines in food. (*Pure & Appl. Chem.*, Vol. 51, No. 6, 1979 pp. 1367-1374).

See: Lipids, Carbohydrates, Amino Acids.

INFRARED SPECTRA

Recommendations for the Presentation of Infrared Absorption Spectra in Data Collections—A. Condensed Phases (*Pure & Appl. Chem.*, 50, 1978, pp. 231-236).

Recommendations for the presentation of Infrared Absorption Spectra in Data Coiiections (Provisional Nomenciature Appendix No. 50, September 1976).

See: Molecular Force Constants.

INORGANIC CHEMISTRY

Nomenclature of Inorganic Chemistry—Isotopicaiiy modified compounds. (*Pure & Appl. Chem.*, Voi. 51, No. 9 (1979) pp. 1981-1994).

Nomenciature of Inorganic Chemistry (*Pure & Appl. Chem.*, Voi. 28, No. 1 1971, pp. 1-110). Aiso pubiished as a book popularly known as the "Red Book" by Pergamon Press, Oxford.

See: Nitrogen, Carbon, Solution Chemistry, Atomic Weights, Boron Compounds, Equiiibria.

INSECTICIDES

Definitions and guideiines for describing and evaiuating pesticide residues. (*Pure & Appl. Chem.*, Vol. 51, No. 3, 1979, pp. 677).

Toxaphene (camphechlor). A spectrai report. (*Pure & Appl. Chem.*, Vol. 51, No. 7, 1979, pp. 1583-1602).

Status report on Ciean-up and determination procedures. (*Pure & Appl. Chem.*, Voi. 51, No. 7, 1979, pp. 1603-1615).

Recommended methods for the determination of residues of pyrethrins and piperonyi butoxide. (*Pure & Appl. Chem.*, Voi. 51, No. 7, 1979, pp. 1615-1623).

ION EXCHANGE

Recommendations on Ion Exchange Nomenciature (*Pure & Appl. Chem.*, Voi. 29, No. 4, 1972, pp. 617-624).

LIPIDS

Nomenclature of Lipids (Provisionai Nomenciature Appendix No. 67, December, 1977).

LIQUID-LIQUID DISTRIBUTION

Proposed Terminology and Symboi for the Transfer of Soiutes from One Soivent to Another (*Pure & Appl. Chem.*, No. 6, 1978, p. 587).

Recommended Nomenciature for Liquid Liquid Distribution (Soivent Extraction): revised 1975 (Provisionai Nomenclature Appendix No. 63, Juiy 1977).

MACROMOLECULES

See: Polymers, Proteins.

MASS SPECTROMETRY

Recommendations for Symboiism and Nomenclature for Mass Spectroscopy (*Pure & Appl. Chem.*, 50, 1978, pp. 65-73).

Recommendations for Nomenclature of Mass Spectrometry (*Pure & Appl. Chem.*, Voi. 37, No. 4, 1974, pp. 469-480).

MICELLES

Reporting experimental data dealing with criticai miceiiization concentrations (c.m.c's) of aqueous surfactant systems. (*Pure & Appl. Chem.*, Vol. 51, No. 5. 1979, pp. 1083).

MICROCHEMICAL ANALYSIS

Terminoiogy for Scales of Working in Microchemicai Anaiysis (*Pure & Appl. Chem.*, Vol. 51, No. 1, 1979 p. 43).

General Aspects of Trace Analyticai Methods.
II. Standard Reference Materials for Trace Anaiysis (*Pure & Appl. Chem.*, No. 11/12, 1978, pp. 1531-1700).
III. Contamination in Trace Analysis (*Pure & Appl. Chem.*, No. 11/12, 1978, p. 1519).

Recommendations on Nomenciature of Scaies of Working in Anaiysis (Provisional Nomenclature Appendix No. 18, February 1972).

MOLECULAR FORCE CONSTANTS

Definition and Symbolism of Moiecular Force Constants (*Pure & Appl. Chem.*, No. 11/12, 1978, p. 1707).

MOSSBAUER SPECTRA

Nomenclature and Conventions for Reporting Mossbauer Spectroscopic Data (*Pure & Appl. Chem.*, Voi. 45, Nos. 3-4, 1976, pp. 211-216).

NITROGEN

Nomenciature of Hydrides of Nitrogen and Derived Cations, Anions and Ligands (*Info. Bull.*, No. 2, 1978).

NMR DATA

Recommendations for the Presentation of NMR Data for Publication in Chemical Journals—B. Conventions Relating to Spectra from Nuclei Other than protons (*Pure & Appl. Chem.*, Vol. 45, Nos. 3-4, 1976, pp. 217-219).

Recommendations for the Presentation of NMR Data for Publication in Chemical Journals—A. Conventions Relating to Proton Spectra (*Pure & Appl. Chem.*, Vol. 29, No. 4, 1972, pp. 625-628).

NUCLEAR CHEMISTRY

Radioactive ^{63}Ni in biological research. (*Pure & Appl. Chem.*, Vol. 51, No. 6, 1979, pp. 1375-1389).

Recommendations on Nomenclature for Nuclear Chemistry (Provisional Nomenclature Appendix No. 25, June 1972).

Reference materials for trace analysis by radioanalytical methods. (*Pure & Appl. Chem.*, Vol. 51, No. 5, 1979).

Procedure for measurement of 14-MeV neutron fluxes from accelerators for activation analysis. (*Pure & Appl. Chem.*, Vol. 49, No. 3, 1977).

NUCLEIC ACIDS

Abbreviations and Symbols for Nuclei Acids, Polynucleotides and their Constituents (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 277-290).

ORGANIC CHEMISTRY

Nomenclature of Organic Chemistry (a 550 page hardcover volume, 1979, available from Pergamon Press, Oxford).
Section A: Hydrocarbons.
Section B: Fundamental Heterocyclic Systems.
Section C: Characteristic Groups containing carbon, Hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and Tellurium.
Section D: Organic Compounds containing elements that are not exclusively carbon, hydrogen, oxygen, nitrogen, halogen, sulfur, selenium and tellurium.
Section E: Stereochemistry
Section F: General Principles for the naming of natural products and related compounds.
Section H: Isotopically modified compounds.

Revision of the extended Hantzsch-Widman System of Nomenclature for Heteromonocycles (*Pure & Appl. Chem.*, Vol. 51, No. 9, 1979, pp. 1995-2003).

Nomenclature of Tetrapyroles (*Pure & Appl. Chem.*, Vol. 51, No. 11, 1979, pp. 2251-2304).

See: Physical Organic Chemistry.

PH

Recommended Reference Materials for Realization of Physiochemical Properties: Potentiometric Ion Activities (*Pure & Appl. Chem.*, No. 11/12, 1978, p. 1485).

PHOSPHOROUS COMPOUNDS

Nomenclature of Phosphorous-containing Compounds of Biochemical Importance. (Provisional Nomenclature Appendix No. 66, December 1977).

PHYSICAL ORGANIC CHEMISTRY

Glossary of terms used in physical organic chemistry. (*Pure & Appl. Chem.*, Vol. 51, No. 8, 1979, pp. 1725-1802).

PHYSICOCHEMICAL QUANTITIES AND UNITS

Manual of symbols and Terminology for Physicochemical Quantities and Units. (*Pure & Appl. Chem.*, Vol. 51, No. 1. 1979 pp. 1). (Also available as soft-cover booklet from Pergamon Press, Oxford.)

See: pH, Spectrochemical Analysis, Reference Materials.

POLYMERS

Sterochemical definitions and notations relating to polymers. (*Pure & Appl. Chem.*, Vol. 48, No. 3, 1976, pp. 373-385).

List of Standard Abbreviations (Symbols) for Synthetic Polymers and Polymer Materials (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 473-476).

Basic Definitions of Terms Relating to Polymers (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 477-491).

PRESENTATION OF DATA

See: NMR, Raman Spectra, Thermodynamics, Mossbauer Spectra, Electron Spectroscopy, Infrared Spectra, Quantum Chemistry, Micelles, Chromatography, Chemical Analysis, Spectrochemical Analysis, Electrochemistry, Equilibria, Surface Analysis.

PROTEINS & PEPTIDES

Nomenclature of Peptide Hormones (Provisional Nomenclature Appendix No. 48, September 1975).

Abbreviations and Symbols for the Description of Conformation of Polypeptide Chains (*Pure & Appl. Chem.*, Vol. 40, No. 3, 1974, pp. 291-308).

Abbreviated Nomenclature of Synthetic Polypeptides (Polymerized Amino Acids) (*Pure & Appl. Chem.*, Vol. 33, Nos. 2-3, 1973, pp. 437-444).

Nomenclature of Iron-Sulfur Proteins (Provisional Nomenclature Appendix No. 32, August, 1973).

A One-letter Notation for Amino Acid Sequences (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 639-645).

Rules for Naming Synthetic Modifications of Natural Peptides (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 647-653).

QUANTUM CHEMISTRY

Expression of Results in Quantum Chemistry (*Pure & Appl. Chem.*, Vol. 50, 1978, pp. 75-79).

QUINONES

Nomenclature of Quinones with Isoprenoid Side-Chains (*Pure & Appl. Chem.*, Vol. 38, No. 3, 1974, pp. 439-447).

RADIATION

Recommended Names and Symbols for Light and Related Electromagnetic Radiation (Manual of Symbols and Terminology for Physicochemical Quantities and Units, 1979, Section 2.8, Pergamon Press, Oxford).

RAMAN SPECTRA

Recommendations for the Presentation of Raman Spectra for Cataloging and Documentation in Permanent Data Collections (*Pure & Appl. Chem.*, Vol. 36, Nos. 1-2, 1973, 275-278).

REFERENCE MATERIALS

Recommended Reference Materials for the Realization of Physicochemical Properties:

- General Introduction (*Pure & Appl. Chem.*, Vol. 40, 1974, pp. 391).
- Enthalpy (*Pure & Appl. Chem.*, Vol. 40, 1974, pp. 399).
- Optical Rotation (*Pure & Appl. Chem.*, Vol. 40, 1974, pp. 451).
- Surface Tension (*Pure & Appl. Chem.*, Vol. 40, 1974, pp. 457).
- Optical Refraction (*Pure & Appl. Chem.*, Vol. 40, 1974, pp. 463).
- Molecular Weight (*Pure & Appl. Chem.*, Vol. 48, 1976, pp. 241).
- Absorbance and Wavelength (*Pure & Appl. Chem.*, Vol. 49, 1977, pp. 661).
- Pressure-volume-temperature relationships (*Pure & Appl. Chem.*, Vol. 49, 1977, pp. 1437).
- Reflectance (*Pure & Appl. Chem.*, Vol. 50, 1978, pp. 1477).
- Potentiometric ion activities (*Pure & Appl. Chem.*, Vol. 50, 1978, pp. 1485).
- Testing Distellation Columns (*Pure & Appl. Chem.*, Vol. 51, 1979, No. 12).

See: Nuclear Chemistry.

SOLUTION CHEMISTRY

Conditional diffusion coefficients of ions and molecules in solution. An appraisal of the conditions and methods of measurement (*Pure & Appl. Chem.*, Vol. 51, No. 7, pp. 1575-1582, 1979).

Recommendations on the Usage of the Terms "Equivalent" and "Normal" (*Pure & Appl. Chem.*, Vol. 50, 1978, pp. 325-338).

Recommendations on Nomenclature for Contamination Phenomena in Precipitation from Aqueous Solutions (*Pure & Appl. Chem.*, Vol. 37, No. 4, 1974, pp. 463-468).

See: Liquid-Liquid distribution
Electrochemistry (For Transport Phenomena).

SOLVENT EXTRACTION

See: Liquid-Liquid Distribution.

SPECTROCHEMICAL ANALYSIS

Recommendations for Publication of Papers on Methods of Molecular Absorption Spectrophotometry in Solution between 200 and 800mm (*Pure & Appl. Chem.*, Vol. 50, 1978, pp. 237-242).

Recommended Reference Materials for Realization of Physiochemical Properties; Reflectance (*Pure & Appl. Chem.*, No. 11/12, 1978, p. 1477).

Nomenclature, Symbols, Units and Their Usage in Spectrochemical analysis—IV. X-Ray Emission Spectroscopy (Provisional Nomenclature Appendix No. 54, December, 1976).

Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—II. Data Interpretation (*Pure & Appl. Chem.*, Vol. 45, No. 2, 1976, pp. 99-103).

Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—III. Analytical Flame Spectroscopy and Associated Non-Flame Procedures (*Pure & Appl. Chem.*, Vol. 45, No. 2, 1976, pp. 105-123).

Nomenclature, Symbols, Units and Their Usage in Spectrochemical Analysis—1. General Atomic Emission Spectroscopy (*Pure & Appl. Chem.*, Vol. 30, Nos. 3-4, 1972, pp. 651-679).

See: Infrared Spectra, Mass Spectrometry, Electron Spectroscopy, Raman Spectra, NMR, Reference materials, Chemical Analysis.

STEROIDS

Nomenclature of Steroids (*Pure & Appl. Chem.*, Vol. 31, Nos. 1-2, 1972 pp. 283-322).

See: Chemical Analysis

SURFACE CHEMISTRY

General aspects of trace analytical methods—IV. Recommendations for nomenclature, standard procedures and reporting of experimental data for surface analysis techniques (*Pure & Appl. Chem.*, Vol. 51, No. 11, 1979, pp. 2243-2250).

Definitions, Terminology and Symbols in Colloid and Surface Chemistry—II. Heterogenous Catalysis (*Pure & Appl. Chem.*, Vol. 46, No. 1, 1976, pp. 71-90).

Definitions, Terminology and Symbols in Colloid and Surface Chemistry—I. (*Pure & Appl. Chem.*, Vol. 31, No. 4, 1972, pp. 577-638).

THERMODYNAMICS

Recommendations for Nomenclature of Thermal Analysis—II. DTA and TG Apparatus and Technique, III. DTA and TG Curves (Provisional Nomenclature Appendix No. 64, July, 1977).

Recommendations for Nomenclature of Thermal Analysis (*Pure & Appl. Chem.*, Vol. 37, No. 4, 1974, pp. 439-444).

A Guide to Procedures for the Publication of Thermodynamics Data (*Pure & Appl. Chem.*, Vol. 29, No. 1-3, 1972, pp. 395-408).

TOCOPHEROLS

Nomenclature of Tocopherols and Related Compounds (Provisional Nomenclature Appendix No. 47, September 1975).

VITAMINS

Nomenclature for Vitamin B-6 and Related Compounds (*Pure & Appl. Chem.*, Vol. 33, Nos. 2-3, 1973, pp. 445-452).

X-RAY SPECTROSCOPY

See: Spectrochemical Analysis.

ZEOLITES

Chemical nomenclature and formulation of compositions of synthetic and natural zeolites. (*Pure & Appl. Chem.*, Vol. 51, No. 5, 1979, pp. 1091).

CONFERENCES

1980

NUCLEAR METHODS IN R&D

April 14-17. 4th Int'l Conference on Nuclear Methods in Environmental and Energy research. Colombia, U.S.A.
(Dr. James Vogt, 226 Research Reactor Facility, University of Missouri, Columbia, MO 65201, U.S.A.)

STATISTICAL MECHANICS

April 17-23. 14th Int'l Conference on Thermodynamics and Statistical Mechanics. Edmonton, Canada.
(D. D. Betts, Statphys 14, Dept. of Physics, University of Alberta, T6G 2J1, Canada)

BIO-ENERGY

April 21-25. Bio-Energy World Congress and Exposition. Atlanta, Georgia, U.S.A.
(P. Schauffler, Development Dir., BioEnergy Council, (BEC), 1625 Eye St. NW, Suite 825-A, Washington, 20006, U.S.A.)

TRACE ELEMENTS

April 27-29. 1st Int'l Workshop on Trace Element Analytical Chemistry in Medicine and Biology. Neuherberg, Germany.
(Dr. P. Schramel, Physikalisch—Technische Abteilung, Ges für Strahlen—und Umweltforschung mbH. Ingolstadter, Landstrasse 1, Post Oberschleissheim D-8042, Neuherberg, Federal Republic of Germany)

ENVIRONMENTAL MONITORING

April. 14th Int'l Symposium on Remote Sensing of the Environment. San Jose, Costa Rica.
(J. J. Cook, Environmental Research Institute of Michigan, (ERIM), Ctr. for Remote Sensing Info. & Analysis, Box 8618, Ann Arbor, MI 48107, U.S.A.)

POLLUTED ATMOSPHERES

May 5-7. 14th Int'l Colloquium on Polluted Atmospheres. Paris, France.
(M. Benarie, National Institute for Applied Chemical Research (IRChA), BP 1, 91710 Vert-le-Petit, France)

CEREAL CHEMISTRY

May 7-9. 10th Congress of the Int'l Assoc. of Cereal Chemistry. Vienna, Austria.
(Int'l Assoc. for Cereal Chemistry, Schmidgasse No. 3-7, A-2320 Schwechat, Austria)

ENVIRONMENTAL POLLUTION

May 8-9. Int'l Environmental Pollution Conference. Toronto, Canada.
(Alena Enterprises of Canada (ALENCA), P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada)

NON-METALS IN METALS

May 10-13 Non-metals in Metals. Berlin, F.R. Germany.
(Gesellschaft Deutscher Chemiker, Abt. Fachgruppen, Postfach 90440, D-6000 Frankfurt(Main) 90, Federal Republic of Germany)

GENERAL MEETING ANZAAS

May 12-16. 50th Congress of the Australian and New Zealand Association for Advancement of Science. Adelaide, Australia.
(Dr. J. R. Best, 141 Rundle Mall, Adelaide, SA 5000, Australia)

GEOCHEMISTRY

May 12-16. Int'l Archaean Symposium, Perth, Australia.
(J. A. Hallberg, Archean Symposium, CSIRO, Division of Mineralogy, Private Bag, Wembly, Australia 6014)

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

CONFERENCES 1980

FIRE RETARDANTS
May 15-16, 7th Int'l Symposium on Flammability & Fire Retardants. New Orleans, U.S.A.
Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

ORGANIC ELECTROCHEMISTRY
May 19-23. Organic Electrochemistry. Rodez, France.
(Prof. G. Cauquis, Commissariat a L'énergie Atomique, Centre D'Etudes Nucléaires de Grenoble, Avenue des Martyrs, F-38 Grenoble, France)

PH SCALE
May or June. Harmonization of PH Scale Recommendations. Lisbon or Milan.
(Dr. A. K. Covington, Dept. of Physical Chemistry, University of Newcastle, Newcastle upon Tyne, NE1 7RU, U.K.)

HETROCYCLES IN BIO-ORGANIC CHEM.
May 20-24. 28th Event of the European Federation of Chemical Engineering. Noordwijkerhout, Netherlands.
(Dr. P. Smit, L. H. Wageningen, Laboratorium voor Organische Scheikunde, De Dreijen 5, 6703 BC Wageningen, Netherlands)

OXYGEN & OXY-RADICALS
May 25-29. Int'l Conference on Oxygen and Oxy-Radicals in Chemistry and Biology. Austin, U.S.A.
(Dr. E. L. Powers, Patterson Lab. Bldg, 131, University of Texas, Austin, TX78712, U.S.A.)

ASBESTOS
May 26-30. 4th Int'l Conference on Asbestos. Turin, Italy.
Vanni Badino Istituto di Arte Mineraria Politecnico, Corso Duca degli Abruzzi 24, 10129, Torino, Italy)

ION EXCHANGE
May 27-30. 4th Symposium on Ion Exchange. Balaton Lake, Hungary.
(Prof. J. Inczedy, Organizing Committee, 4th Symposium on Ion Exchange, P.O. Box 28, Veszprem, Hungary H-8201)

POLLUTANT ANALYSIS
May 28-30. 10th Annual Symposium on the Analytical Chemistry of Pollutants. Dortmund, F.R. Germany.
(Dr. J. Wendenburg, Gesellschaft Deutscher Chemiker, P.O. Box 90 04 40, D - 6000, Frankfurt am Main 90, Federal Republic of Germany)

THEORETICAL PHOTOCHEMISTRY
June. Summer School on Theoretical Photochemistry.
(Sponsored by the Inter-American Photochemical Society)
Salt Lake City, Utah, U.S.A.
(Prof. J. Michl, Dept. of Chemistry, University of Utah, Salt Lake City, UT 84112, U.S.A.)

SOLUTE-SOLVENT INTERACTIONS
June 2-6. 5th Int'l Symposium of Solute-Solute-Solvent Interactions. Florence, Italy.
(Prof. I. Bertini, Faculta di Farmacia, Istituto di Chimica Generale e Inorganica, Universita degli Studi de Firenze, Via Gino Capponi 7, I-50121 Firenze, Italy)

ULTRAVIOLET RADIATION
June 2-6. 6th Int'l Conference of Ultraviolet Radiation Physics. Charlottesville, U.S.A.
(Dr. R. C. Elton, Code 5504, US Naval Research Laboratory, Washington, D.C. 20375, U.S.A.)

ZEOLITES
June 2-6. 5th Int'l Conference on Zeolites, Naples, Italy.
(Prof. R. Sersale, Istituto di Chimia Applicata, Universita di Napoli, Piazzale Tecchio, I-80125 Napoli, Italy)

PRECIOUS METALS
June 3-5. 4th Int'l Precious Metals Conference. Ontario, Canada.
(Ricard O McGachie, Johnson Matthey Ltd., 130, Gidden Road, Brampton, Ontario, L6W 3M8, Canada)

CHROMATOGRAPHY
June 5-6. 3rd World Chromatography Conference. Zurich, Switzerland.
(Alena Enterprises of Canada, (ALENCA)P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada)

ATOMIC PLASMA
June 6-11. Int'l Conference on Developments in Atomic Plasma Spectrochemical Analyses. San Juan, Puerto Rico.
(Winter Conference 1980, I.C.P., Information Newsletter, Chemistry - GRC Tower 1, University of Mass., Amherst, MA 01003, U.S.A.)

CHEMISTRY / CANADA
June 8-11. 63rd Conference and Exhibition of the Chemical Institute of Canada, Ottawa, Ontario, Canada.
(Dr. G. S. Kell, Division of Chemistry, National Research Council, Ottawa, Ontario, K1A 0R9, Canada)

XENOBIOCHEMISTRY
June 9-13. Int'l Conference on Xenobiochemistry. Bratislava, Czechoslovakia.
(Secretariat: Biochemical Institute, Comenius University, Kolinciakova 8, 880 34 Bratislava, Czechoslovakia)

URETHANE CHEMISTRY
June 9-13. Int'l Urethane Conference. Strasbourg, France.
(Dr. Franzkarl Brochhagen, Bayer AG, PU-A, 5090 Leverkusen, F.R. Germany)

ORGANIC SULPHUR CHEMISTRY
June 9-14. 9th Int'l Symposium on Organic Sulphur Chemistry, Riga, USSR.
(Organizing Committee, Institute of Organic Synthesis of the Latvian USSR Academy of Sciences, Aizkraukles 21, 226006 Riga, USSR)

MASS SPECTROMETRY IN BIOLOGY
June 9-14. 3rd Int'l Symposium on Qantitative Mass Spectrometry in the Life Sciences. Ghent, Belgium.
(Prof. Dr. A. de Leenheer, Sec., Int'l Symposium on Quantitative Mass Spectrometry in Life Sciences (Org. Committee) (ISQMSLS) m c/o Lab v Med Biochemie en Klinische Analyse, Rijkuniv-Gent, 135, De Pintelaan, B-9000 Ghent, Belgium)

SPECTROMETRY IN LIFE SCIENCES
June 10-13. 3rd Int'l Symposium on Quantitative Mass Spectrometry in Life Sciences. Belgium.
(Prof. A. de Leenheer, Laboratoria voor Medische Biochemie en voor Klinische Analyse, Academisch Ziekenhius, De Pintelaan, 135, B-9000 Gent, Belgium)

POLYMERS
June 11-13. Int'l Symposium on Statistical Mechanics of Phase Transitions in Polymers, Clevland, U.S.A.
(Prof. A. J. Hopfinger, Dept. of Macromolecular Science, Case Institute of Technology, Case Western Reserve University, Cleveland, OH 44106, U.S.A.)

ORGANIC SYNTHESIS
June 15-20. 3rd IUPAC Symposium on Organic Synthesis. Madison, Wisconsin, U.S.A.
(Prof. B. M. Trost, Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, WI 53706, U.S.A.)

CONFERENCES 1980

RADIOPHARMACEUTICAL CHEMISTRY
June 16-20. 3rd Int'l Symposium on Radiopharmaceutical Chemistry. St. Louis, Missouri, U.S.A.
(M. J. Welch, Division of Radiation Sciences, Washington University School of Medicine, 510 South Kingshighway, St. Louis, MI 63110, U.S.A.)

CHEMICAL EDUCATION
June 22-26. 6th Biennial Conference on Chemical Education. Rochester. New York, U.S.A.
(L. Fine, Dept. of Chemistry, Housatonic College, Bridgeport, CT 06608, U.S.A.)

WATER POLLUTION RESEARCH
June 23-27. 10th Int'l Conference on Water Pollution Research. Toronto, Canada.
(Int. Assn. on Water Pollution Research (IAWPR) Chichester House, 278 High Holborn, London WC1 7HF, U.K.)

ORIGIN OF LIFE
June 23-28. 6th Int'l Conference on the Origin of Life. Jerusalem, Israel.
(Dr. M. Paecht-Horowitz, Polymer Dept., Weizman Institute of Science, Rehovot, Israel)

MEDICAL CHEMISTRY
June. 17th National Medical Chemistry Symposium, Rensselaer, New York, U.S.A.
(Division of Medical Chemistry, Amer. Chem. Soc., 1155 16th Street N.W., Washington, D.C. 20036, U.S.A.)

HYDROGEN ENERGY
June 27-July 1. 3rd World Hydrogen Energy Conference. Tokyo, Japan.
(Secretariat, 3rd World Hydrogen Energy Conference, Japan Convention Services Inc, Nippon Press Centre Bldg. 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100, Japan)

METALLIC GLASSES
June 30-July 4. Int'l Conference on Metallic Glasses Technology and Science, Budapest, Hungary.
(K. Tompa, P.O. Box 49, H-1525, Budapest, 114)

CHROMATOGRAPHY
June 30-July 4. 13th Int'l Symposium on Chromatography. Cannes, France.
(Prof. G. Guiochon, Ecole Polytechnique, Laboratorie de Chimie Analytique Physique, Route de Saclay, F-91128 Palaiseau Cedex, France)

CATALYSIS
June 30-July 4. 7th Int'l Congress on Catalysis. Tokyo Japan.
(Prof. I. Yasumori, Department of Chemistry, Tokyo Institute of Technology, 2-12-1 Ookayama, Megmo-ku, Tokyo 152, Japan)

NUCLEAR FUSION RESEARCH
July 1-10. 8th Int'l Conference on Plasma Physics and Controlled Nuclear Fusion Research. Brussels, Belgium.
(John H. Kane, Int. Tech. Conf. Specialists, Tech. Infor., MS: A1-5126 Dept. of Energy, Washington, D.C. 20545, U.S.A.)

MACROCYCLIC LIGANDS
July 3-5. Symposium on Macrocyclic Ligands. Basel, Switzerland.
(Prof. T. A. Kaden, Institut fur Anorganische Chemie der Universitat Basel, Sitalstrasse 51, CH-4056 Basel, Switzerland)

THERMAL ANALYSIS
July 6-12. 6th Int'l Conference on Thermal Analysis. Bayreuth, Federal Republic of Germany.
(ICTA '80) (6th ICTA '80, Postfach 1120, D-8672 Selb, Federal Republic of Germany)

POLYMERS & PLASTICS
July 7-8. European Conference on Polymers & Plastics. Dubrovik, Yugoslavia.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

AMORPHOUS METALS
July 7-11. 4th Int'l Conference on Liquid and Amorphous Metals. Grenoble, France.
(Lam 4, Conference Secretary, ENSEEG, B.P. 44, F-38401 Saint Martin -d'Heres, France)

CARBOHYDRATE CHEMISTRY
July 7-11. 10th Int'l Symposium on Carbohydrate Chemistry. Sydney, Australia.
(Prof. S. J. Angyal, School of Chemistry, University of New South Wales, P.O. Box 1, Kensington, New South Wales 2033, Australia)

TOXICOLOGY
July 7-11. 2nd Int'l Congress on Toxicology, Brussels, Belgium.
(Prof. M. Mercier, Univ. Catholique de Louvain, Lab de Chemie Med. Toxicologie et Bromatologie, Tour Van Helmont, UCL 7369, Ave Emm Mounier 73, 1200 Brussels, Belgium)

COORDINATION CHEMISTRY
July 7-11. 21st Int'l Conference on Coordination Chemistry. Toulouse, France.
(Prof. F. Gallais, 1980 ICCC, Laboratoire de Chemie de Coordination du CNRS, B.P.4142, 31030 Toulouse Cedex, France)

MINERAL AND ENERGY RESOURCES
July 7-17. 26th Int'l Geological Congress: Mineral resources; Energy resources; Geology of the Oceans, of continental margins, of alpine chains, of Europe, of France. Paris, France.
(Dr. W. W. Hutchinson, IUGS Sec. Gen., Geological Survey of Canada, 601 Booth St., Ottawa, K1A OE8, Canada)

PHOTOCHEMISTRY
July 13-19. 8th Symposium on Photochemistry. Seefeld, Austria.
(Prof. J. Schantl, Institut fur Organische und Pharmazeutische Chemie, Universitat Innsbruck, Innrain 52a, A-6020 Innsbruck, Austria)

ORGANIC COATINGS
July 14-18. 6th Int'l Conference in Organic Coatings Science and Technology. Athens, Greece.
(Prof. A. V. Patsis, School of Chemistry, State University of New Paltz, New York, NY 12562, U.S.A.)

WATER ROCK INTERACTIONS
July 14-24. 3rd Int'l Symposium on WaterRock Interactions. Edmonton, Canada.
(B. Hitchon, Alberta Research Council, 11315, 87th Avenue, Edmonton, Alberta, T6G 2C2, Canada

METALLO-ORGANIC COMPOUNDS
July 14-17. Int'l Symposium on Metallo-Organics in Organic Synthesis. Swansea, U.K.
(Dr. John F. Gibson, The Chemical Society, Burlington House, London, W1V 0BN, U.K.)

COORDINATION COMPOUNDS
July-Aug. 4th Microsymposium on the Photochemistry and Photophysics of Coordiantion Compounds. Montreal, Canada.
(Prof. N. Serpone, Dept. of Chemistry, Concordia University, 1455 de Maissoneuve Blvd. West, Montreal, Quebec, H3G IM8, Canada)

FERMENTATION
July 20-27. 6th Int'l Fermentation Symposium. London, Ontario, Canada.
(Prof. J. E. Zajic, Faculty of Engineering Science, University of Western Ontario, London, Ontario, N6A 5B9, Canada)

PHOTOBIOLOGY
July 20-25. 8th Int'l Congress on Photobiology. Strasbourg, France.
(M. Charlier, Congrès International de Photobiologie, Centre de Biophysique Moléculaire, 1A Avenue de la Recherche Scientifique, 45045 Orléans Cedex, France)

ANALYTICAL CHEMISTRY
July 20-26. Int'l Conference on Analytical Chemistry; SAC 80. Lancaster, U.K.
(Dr. J. D. R. Thomas, Department of Chemistry, UWIST, King Edward VII Avenue, Cardiff, CF1 3NU, U.K.)

GERMANIUM, TIN AND LEAD
July 21-25. 3rd Int'l Conference on the Organometallic and Coordination Chemistry of Germanium, Tin and Lead. Dortmund, Federal Republic of Germany
(Dr. W. Fritsche, Gesellschaft Deutscher Chemiker, P.O. Box 900 9 440, D-6000 Frankfurt, Federal Republic of Germany)

STEREOELECTRONIC EFFECTS

July 21-25. Int'l Symposium on Stereolectronic Effects in Organic Chemistry. St. Andrews, U.K.
(Dr. John F. Gibson, The Chemical Society, Burlington House, London, W1V 0BN, U.K.)

IMMUNOLOGY

July 21-26. 4th Int'l Congress of Immunology. Paris, France.
(Dr. A. L. de Weck, Institut fur Klinische Immunologie, Inselspital, 3010 Berne, Switzerland)

CHEMISTRY IN AFRICAN DEVELOPMENT

July 28-Aug. I. The first Int'l Chemistry Conference in Africa entitled "Chemistry in the Development and Environment of Africa". Nairobi, Kenya.
(Dr. S. Wandiga, Chairman Dept. of Chemistry, Univ. of Nairobi, P.O. Box 30197, Nairobi, Kenya)

PHOTOCHEMICAL ENERGY STORAGE

July 3-8. 3rd Int'l Conference on Photochemical Conversion and Storage of Solar Energy. Colorado, U.S.A.
(Dr. J. S. Connolly, Solar Energy Research Institute, 1536, Cole Boul, Golden, CO 80401, U.S.A.)

PHOTOSYNTHESIS

July or Aug. 5th Int'l Congress on Photosynthesis. Corfu, Greece.
(Dr. G. Akoyunoglou, IPC, Dept. of Biology, Nuclear Research Centre, Demokritos, Aghia Parasheri, Athens, Greece)

SOLAR ENERGY

August 3-8. 3th Int. Conference on Photochemical Conversion and Storage of Solar Energy. Colorado, U.S.A.
(Conference Group, SERI, 1536 Cole Boulevard, Boulder, CO 80401, U.S.A.

PHARMACOLOGY

August 3-8. World Conference on Clinical Pharmacology and Therapeutics. London, U.K.
(Prof. C. T. Dollery, Dept. of Clinical Pharmacology, Royal Postgraduate Medical School, Ducane Rd., London, W12 OHS, U.K.)

RAMAN SPECTROSCOPY

August 4-9. 7th Int'l Conference on Raman Spectroscopy. Ottawa, Canada.
(Mr. K. Charbonneau, Exec. Sec., National Research Council of Canada, Ottawa, Ontario, K1A OR6, Canada)

POLYVINYL CHLORIDE

August 10-15. 3rd Int'l Symposium on Polyvinyl Chloride. Cleveland, Ohio, U.S.A.
(Dr. E. A. Collins, Diamond Shamrock Corporation, P.O. Box 348, Painesville, Ohio 44077, U.S.A.)

NON-AQUEOUS SOLUTIONS

August 11-15. 7th Int'l Conference on Non-Aqueous Solutions. Regensburg, Federal Republic of Germany.
(Prof. J. Barthel, Institut fur Chemie, Universitat Regensberg, Universitatstrasse 31 - Postfach, D-8400 Regensberg, Federal Republic of Germany)

COMBUSTION

August 17-22. 18th Int'l Symposium on Combustion. Waterloo, Canada.
(Mrs. M. C. Salamony, Exec. Sec., Combustion Institute, The (TCI), 986 Union Trust Bldg., Pittsburgh, Pennsylvania 15219, U.S.A.)

HISTO- AND CYTOCHEMISTRY

August 17-22. 5th Int'l Histochemistry Congress. Brighton, U.K.
(Secretariat, 5th International Histochemistry and Cytochemistry Congress, Royal Microscopical Society, 37-38 St. Clements, Oxford, OX4 IAJ, U.K.)

PHYSICAL ORGANIC CHEMISTRY

August 17-22. 5th IUPAC Conference on Physical Organic Chemistry, Santa Cruz, California, U.S.A.
(Prof. J. F. Bunnett, Division of Natural Sciences—University of California, Sant Cruz, CA 95064, U.S.A.)

POLYMER COMPATIBILITY

August 17-22. International Symposium on Polymer Compatibility and Incompatibility: Principles and Practice, Michigan, U.S.A.
(Symposium Secretary, MMI, 1910 West St. Andrews Road, Midland, MI 48640, U.S.A.)

ENERGY CONVERSION

August 18-22. 15th Intersociety Energy Conversion Engineering Conference. Seattle, Washington, U.S.A.
(S. Silverman, 19630 Marine View Drive, S.W., Seattle, WA, U.S.A.)

TRANSITION METALS

August 18-22. Int'l Conference on the Physics of Transition Metals. Leeds, U.K.
(Meetings Officer, Institute of Physics, 47 Belgrave Square, London, U.K.)

ATMOSPHERIC PROCESSES

August 18-22. Symposium on Radiative Processes in the Atmosphere, Colorado, U.S.A.
(S. Ruttenberg, NCAR, P.O. Box 3000, Boulder, Colorado 80307, U.S.A.)

BIOCHEMISTRY

August 24-29. 13th Meeting of the Federation of European Biochemical Society. Jerusalem, Israel.
(Prof. N. Sharon, Weizman Institute of Science, Rehovot, Israel)

NORTH AMERICAN CHEMICAL CONGRESS

August 24-29. 2nd Chemical Congress of the North American Continent. San Francisco, California, U.S.A.
(A. T. Winstead, Head, Meetings & Div. Activities, American Chemical Society (ACS), 1155 16th Street, NW, Washington, D.C. 20036, U.S.A.)

POLYMERIZATION OF ORGANIC COATINGS

August 25-27. Photopolymerization and Photocross-linking of Organic Coatings. Stockholm, Sweden.
(Prof. A. Ranby, Dept. of Polymer Technology, The Royal Institute of Technology. S-100 44, Stockholm)

MICROCHEMISTRY

August 25-30. 8th Int'l Microchemical Symposium. Graz, Austria.
(Prof. Dr. M. Grasserbauer, Secretary General, c/o Interconvention, P.O. Box 35, A - 1095 Wien, Austria)

MAGNETIC RESONANCE

August 25-30. ISMAR - Ampere international Conference on Magnetic Resonance. Delft, The Netherlands.
(Prof. J. Smidt, Delft University of Technology, Dept. of Applied Physics, P.O. Box 5046, NL-2600 GA, Delft, Netherlands)

THERMODYNAMICS

August 26-29. 6th Int'l Conference on Thermodynamics. Merseburg, GDR.
(Prof. Dr. Margit T. Ratzsch, Technische Hochschule "Carl Schorlemmer" Leuna-Merseburg, Geusaer Strasse, DDR -42 Merseburg 6, German Democratic Republic)

HYDROGEN IN METALS

August 26-31. Int'l Conference on Hydrogen Effects in Metals. Moran, Wyoming, U.S.A.
(Prof. I. M. Berstein, Dept. of Metallurgy & Materials Sci., Carnegie-Mellon Univ., Pittsburgh, PA 15213, U.S.A.)

OZONE

August. Ozone Symposium. Boulder, Colorado, U.S.A.
(Mr. S. Ruttenberg, Sec. Int'l Assoc. of Meteorology & Atmospheric Physics, NCAR, P.O. Box 3000, Boulder, CO 80307, U.S.A.)

FLOW PROPERTIES

Aug. 31-Sept. 6. 8th Int'l Congress of Rheology. Naples, Italy.
(Prof. G. Astaria, Istituto di Principi di Ingegneria Chemica, Piazalle Tecchi, 80125, Napoli, Italy)

ORGANIC SUBSTANCES UNDER HIGH PRESSURE
September 1-3. Conference on Chemistry Physics and Technology of Organic Substances under High Pressure. Amsterdam, Netherlands.
(Dr. H. Steinberg, Laboratorium voor Organische Scheikunde, Unviersiteit van Amsterdam, Nieuive Achtergracht, 129, 1018 WS Amsterdam, Netherlands, or Prof. I. M. Ward, Dept. of Physics, University of Leeds, Leeds, LS2 9JT, U.K.)

HOMOGENEOUS CATALYSIS
September 1-3. 2nd Int'l Symposium on Homogeneous Catalysis. Dusseldorf, Germany.
(Dr. W. Fritsche, c/o, Gesellschaft Deutscher Chemiker, P.O. Box 90 04 40, D - 6000, Frankfurt/Main 90, Federal Republic of Germany)

REACTIVITY OF SOLIDS
September 1-6. 9th Int'l Symposium on the Reactivity of Solids. Krakow, Poland.
(Dr. J. Nowotny, Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, ul. Niezapominajek, 30-239, Krakow, Poland)

COMPUTERS IN CHEMICAL ENGINEERING
September 2-5. Chemplant 80 - Symposium of the Working Party on Routine Calculations and Use of Computers in Chemical Engineering. Heviz, Hungary.
(European Federation of Chemical Engineering, Chemical Society, Anker Koz 1, 1061 Budapest VI, Hungary)

MEDICINAL CHEMISTRY
September 2-5. 7th Int'l Symposium on Medicinal Chemistry. Torremolinas, Spain.
(Prof. R. Madronero, Sociedad Espanola de Quimica Terapeutica, Juan de la Cierva 3, Madrid 6, Spain)

MICROBIAL ADHESION TO SURFACES
September 3-5. Microbial Adhesion to Surfaces, an interdisciplinary meeting. Reading, U.K.
(Dr. P. R. Rutter, c/o, The Conference Secretariat, Society of Chemical Industry, 14, Belgrave Square, London, SW1X 8PS, U.K.)

POLMERIZATION MECHANISMS
September 3-5. Int'l Symposium on Polymerization Mechanisms. Liverpool, U.K.
(Prof. G. C. Eastmond, Donnan Laboratories, Dept. of Inorganic, Physical & Industrial Chemistry, University of Liverpool, P.O. Box 147, Grove St., Liverpool, L69 3BX, U.K.)

ADHESIVES
September 3-5. Int'l Conference on Adhesion and Adhesives. Durham, U.K.
(Mrs. Sheila M. Serjeant, Plastics and Rubber Institute, 11, Hobart Place, London, SW1W OHL, U.K.)

TOXICOLOGY OF NICKEL
September 3-5. 2nd Int'l Conference on Environmental & Occupational Toxicology of Nickel, Swansea, U.K.
(Prof. F. W. Sunderman, Jr., Dept. of Laboratory Medicine, University of Connecticut, P.O. Box G, Farmington, Connecticut, 06032, U.S.A.)

EUROCOATINGS '80
September 4-5 2nd European Conference of Paints & Coatings. Frankfurt, Germany.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

SOLVENT EXTRACTION
September 6-12. Int'l Solvent Extraction Conference. Liege, Belgium.
(Secretary ISEC '80, Dept. of Chemistry, University of Liege, Sart Tilman, B-4000, Liege, Belgium)

COAL AS A CHEMICAL FEEDSTOCK
September 7-11. Int'l Conference on coal as a feedstock for the Chemical Industry. Sheffield, U.K.
(Dr. E. Rothwell, Dept. of Chemical Engineering and Fuel Technology, University of Sheffield, Mappin Street, Sheffield, S1 3JD, U.K.)

ANALYTICAL CHEM./ SPECTROSCOPY
September 7-12. 7th Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies. Philadelphia, U.S.A.
(J. A. Williamson Dupont Co., Instrument Products Div., Wilmington, Del. U.S.A.)

MACROMOLECULES
September 7-13. Int'l Symposium on Macromolecules. Florence, Italy.
(Prof. F. Ciardelli, Istituto Chemica Organica Industriale, Via Risorgimento 35, I -56100 Pisa, Italy)

PHOTOSYNTHESIS
September 7-13. 5th Int. Congress on Photosynthesis. Greece.
(Dr. G. Akoyunoglou, IPC Dept. of Biology, Nuclear Research Center Demokritos, Aghia Parasheri, Athens, Greece)

WORLD ENERGY
September 8-12. 11th World Energy Conference. Munchen, Germany.
(Dr. E. Ruttley, WEC, Intern, Executive Council, c/o, British National Committee, 34, James Street, London, SW1A 1HD, U.K.)

FIRE RETARDANTS
September 9-10. 4th European Conference on Flammability and Fire Retardants. Frankfurt, Germany.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

CRYSTAL GROWTH
September 10-16. 6th Int'l Conference on Crystal Growth.
September 17-25. Int'l Specialist school on Crystal Growth. Moscow, USSR.
(Dr. E. I. Givargizov, Institute of Crystallography, USSR Academy of Sciences, Lenlnskii Prosp. 59, SU-117333, Moscow, USSR.

OXYGEN
September 15-18. 2nd BOC Priestly Conference (Theme: production, storage and transport of Oxygen In living systems and industry). Birmingham, U.K.
(Dr. John F. Gibson, Assistant Secretary (Scientific & Educational), The Chemical Society, Burlington House, London W1V 0BN, U.K.)

SAFETY IN PROCESS INDUSTRIES
September 15-19. 3rd Int'l Symposium on Loss Prevention and Safety Promotion in the Process Industries. Basle, Switzerland.
(European Federation of Chemical Engineering, 3rd. Int'l Symp. on Loss Prevention and Safety Promotion in the Process Industries, P.O. Box 141, 4007 Basle, Switzerland)

FLUORINE CHEMISTRY
September 15-19. 7th European Symposium on Fluorine Chemistry. Padua, Italy.
(Prof. G. P. Gambaretto, Istituto di Chemica Industriale della Facolta di Marzola 9, 35100 Padua, Italy)

CORROSION INHIBITORS
September 15-19. 5th European Symposium on Corrosion Inhibitors. Ferrara, Italy.
(Corrosion Study Centre 'A Dacco' University of Ferrara, Via L Borsari 46, I - 44100 Ferrara, Italy)

MEDICINAL PLANTS
September 15-19. 4th Asian Symposium of Medicinal Plants and Spices. Bangkok, Thailand.
(Dr. Vichai Reutrakul, Dept, of Chemistry, Faculty Science, Mahidol University, Rma VI rd., Thailand, Bangkok 4)

POLYMER NETWORKS
September 15-20. 7th Discussion Conference on Polymer Networks. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelin, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

CONFERENCES 1980

MARINE NATURAL PRODUCTS
September 16-20. 3rd Int'l Symposium on Marine Natural Products. Brussels, Belgium.
(Dr. J. C. Braekman, Faculté des Sciences, Avenue F.D. Roosevelt 50, Université Libre de Brussels, B- 1050, Brussels, Belgium)

CRYSTAL DEFECTS
September 17-21. 3rd Europhysics topical conference on Lattice Defects in Ionic Crystals. Canterbury, U.K.
(The Secretary, Europhysics Topical Conference, Physics Laboratory, The University, Canterbury, Kent, CT2 7NR, U.K.)

NATURAL PRODUCTS
September 21-27. 12th Int'l Symposium on Chemistry of Natural Products, Tenerife, Spain.
(Prof. A. G. Gonzalez, Instituto de Productos Naturales, Carretera la Esperanza 2, La Laguna, Tenerife, Spain)

ASTRONAUTICAL CONGRESS
September 21-28. 31st. Int. Astronautical Congress. Tokyo, Japan.
(International Astronautical Federation, 250 Rue Saint-Jacques, 75005 Paris, France)

COSMETIC RESEARCH
Setember 22-26. 11th Int'l Congress on Cosmetic Research and Technology. Venice, Italy.
(Convention Service Italy, Piazza Mignarelli 4, 00187 Rome, Italy)

SURFACE CHEMISTRY
September 22-26. 8th Int'l Vacuum Congress/4th Int'l Conference on Solid Surfaces. Cannes, France.
(1980 Steering Committee, Société Francaise du Vide, 19 Rue de Renard, 75004, Paris, France)

POLYMERIZATION OF HETEROCYCLES
September 22-26. 21st Prague Microsymposium on Ring-Opening Polymerization of Heterocycles, Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelin, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

CHEMICAL PATHWAYS IN THE ENVIRONMENT
September 22-26. European Conference on Chemical Pathways in the Environment. France.
(Dr. C. Troyanowsky, Société de Chimie Physique, 10, Rue Vauquelin, F-75005, Paris, France)

SYNTHESIS OF NEW ELEMENTS
September 23-27. Int'l Symposium on the Synthesis and Properties of New Elements. Dubna, USSR.
(Prof. Yu Ts. Oganessian, Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, Head Post Office, Box 79, SU-101000 Moscow, USSR)

FRESH WATER FROM THE SEA
September 23-27. 7th Int'l Symposium Fresh Water From the Sea. Amsterdam, Netherlands.
(Prof. A. A. Delyannis, Plastria St. 3, Pefki, Greece)

WATER POLLUTION CONTROL
Sept. 28-Oct. 3. Water Pollution Control Federation Int'l Convention. Atlantic City, N.J., U.S.A.
(R. A. Canham, 3900 Wisconsin Avenue, N.W., Washington D.C. 20016, U.S.A.)

PHYSICS OF FLOW
Sept. 30-Dec. 5. Autumn Course on Physics of Flow in the Oceans, Atmosphere and Deserts. Trieste, Italy.
(International Centre for Theoretical Physics, P.O. Box 586, 1-34100 Trieste, Italy)

ALCOHOLS
October 5-8. 4th Int'l Symposium on Alcohols, and other biomass fuels Technology. Guaruja, State of Sao Paulo, Brazil.
(Instituto De Pesquisas Technologicas - IPT, 4th International Alcohol Symposium, Caixa Postal 7141, 01000 Sao Paulo, Brazil.

ATMOSPHERIC CORROSION
October 5-10. Int'l Symposium on Atmospheric Corrosion. Florida, U.S.A.
(W. H. Ailor, Symposium Chairman, Metallurgical Research Division, Reynold Metal Co., Richmond, VA 23261, U.S.A.)

POLYNUCLEAR AROMATIC HYDROCARBONS
October 7-9. 5th Int'l Symposium on Polynuclear Aromatic Hydrocarbons. Ohio, U.S.A.
(Dr. Ay. Bjorseth, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201, U.S.A.)

SCIENTIFIC DATA
October 8-11. 7th Int'l Conference on Data for Science and Technology. Kyoto, Japan.
(Prof. T. Shimanouchi, Electronics & Info Technology, Tsukuba Univ. Sakura-mura, Niihari-gun, Ibaraki-ken 300-31, Japan)

PESTICIDES AND ARTIFICIAL FERTILIZERS
October 12-16. Int'l Conference on Pesticides and Artificial Fertilizers—Man and the Environment. UNESCO Programme "Man and the Biosphere". Varna, Bulgaria.
(Dr. Todor Popov, Secretaire General du Comite d'Organization, Institu d'hygience et de maladies professionnelles, Bulgaria - Sofia 1431)

CATALYST DEACTIVATION
October 13-15. Int'l Symposium on Catalyst Deactivation: Poisoning, Coke formation, Solid state chemical transformations. Antwerp, Belgium.
(International Symposium "Catalyst Deactivation" Technologisch Instituut - K. VIV, Jan Van Rijswijcklaan 58, B- 2000 Antwerpen, Belgium)

SCIENTIFIC INFORMATION TRANSFER
October 13-17. 2nd Int'l Conference of Scientific Editors. Amsterdam, Netherlands.
(Helena Tombal, Elsevier Scientific Publishing Co., P.O. Box 330, 1000 AH Amsterdam, Netherlands)

WATER CHEMISTRY OF NUCL. REACTORS
October 13-17. Int'l Conference on Water Chemistry of Nuclear Reactor Systems. Bournemouth, U.K.
(The Secretariat, British Nuclear Energy Society at the Institution of Civil Engineers, 1-7, Great George Street, Westminster, London, SW1P 3AA, U.K.)

CRYSTALLINE POLYMERS
October 13-17. Int'l Symposium of Mechanical Properties of Crystalline Polymers. Massachusetts, U.S.A.
(Prof. E. E. Magat, Polymer Science and Engineering Department, University of Massachusetts, Amherst, MA 01003, U.S.A.)

SPECTROSCOPY
October 16-17. 2nd World Spectroscopy Conference. Brussels, Belgium.
(Alena Enterprises of Canada, (ALENCA) P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada)

ELECTROCHEMISTRY
October. Electrochemical Society Int'l Convention. Miami Beach, Florida, U.S.A.
(M. A. Fahner, P.O. Box. 2071, Princeton, NJ 08540, U.S.A.)

ENVIRONMENTAL POLLUTION
October 16-17. Int'l Symposium on Environmental Pollution. Georgia, U.S.A.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

CLEAN AIR
October 20-26. 5th Int'l Clean Air Congress. Buenos Aires, Argentina. (APCA Headquarters, P.O. Box, 2861, Pittsburgh, PA 15230, U.S.A.)

POLYMERS & PLASTICS
November 6-7. Int'l Conference on Polymers & Plastics. New York, U.S.A.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

SPACE GEODESY
November 18-21. Int'l Symposium on Space Geodesy and its Applications. Cannes, France.
(Centre National D'Etudes Spatiales, Department des Affaires Universitaires, 18, Avenue Edouard-Berlin, 31055 Toulouse Cedex, France)

TECHNOLOGY FOR DEVELOPMENT
November 24-28. 1st Int'l Conference on Technology for Development. Canberra, Australia.
(I. E. Aust. 11, National Circuit, Barton, ACT. 2600, Australia)

CLINICAL CHEMISTRY
November. 1st African & Mediterranean Congress of Clinical Chemistry. Milan, Italy.
(1st. African & Mediteranean Congress of Clinical Chemistry, Via Keplero 10, 20124, Milan, Italy)

NITROGEN FIXATION
December 1-5. 4th Int'l Symposium on Nitrogen Fixation. Canberra, Australia.
(Dr. A. H. Gibson, CSIRO Div. of Plant Industry, P.O. Box 1600, Canberra City, ACT 2061, Australia)

BIOCHEMISTRY—ASIA AND OCEANIA
December 14-18. Golden Jubilee of Society of Biological chemists (India) and Second Congress of the Federation of Asian and Oceanic Biochemists. Bangalore, India.
(Mr. S. Krishnamurthy, Soc. of Biol. Chemists (India), Indian Institute of Science, Bangalore 560 012, India)

ENVIRONMENTAL POLLUTION
December 18-19. European Conference of Environmental Pollution. Frankfurt, Germany.
(Vijay Mohan Bhatnagar. Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7, Canada)

1981

TOXICITY
March 4-7. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142-144, Oxford Road, Cowley, Oxford, OX4 2DZ, U.K.)

COLLOIDAL PARTICLE INTERACTIONS
March 16-21. Int'l Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, 2600 Australia)

ARID SOILS
Mar. 29-Apr.4. Int'l Conference on Arid Soils. Jerusalem. Israel.
(Dr. H. Yaalon, Dept. of Geology, The Hebrew University of Jerusalem, Jerusalem 9100, Israel)

BIOTECHNOLOGY
April 6-10. 2nd European Congress on Biotechnology. Eastbourne, U.K.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Sq., London, SW1X 8PS, U.K.)

U.K. CHEMICAL CONGRESS
April 7-9. Chemical Society Annual Congress. Guildford, U.K.
(Chemical Society, Burlington House, London, W1V OBN, U.K.)

METAL-HYDROGEN SYSTEMS
April 13-15. Int'l Symposium on Metal Hydrogen Systems. Miami Beach, Florida, U.S.A.
(Dr. T. Nejat Veziroglu, Director of Clean Energy Research Institute, University of Miami, P.O. Box 248294, Coral Gables, FL 33124, U.S.A.)

MOSSBAUER EFFECT
April 13-17. Int'l Conference on the Application of the Mossbauer Effect. Kashmir, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi - 110012, India)

CHEMISTRY/ASIA AND PACIFIC
Apr. 26-May 1. 1st Asian & Pacific Chemistry Congress. Singapore.
(The Congress Secretary, 1st. ISPAC Congress, Singapore Professional Centre, 129 B Block, Outram Park, Singapore 0316)

TRACE ELEMENT METABOLISM
May. 21-25. 4th Int'l Conference on the Trace Element Metabolism in Man and Animals. Perth, Australia.
(Australian Academy of Science, P.O. Box 783, Canberra City, ACT 2601, Australia)

HETEROGENEOUS & HOMOGENEOUS CATALYSIS
May 25-27. 3rd Int'l Symposium on Relations between Heterogeneous and Homogeneous Catalysis. Groningen, Netherlands.
(Dr. R. S. Downing, Koninklijke/Shell-Laboratorium, Postbus 3003, 1003 AA Amsterdam, The Netherlands)

SCIENCE/PACIFIC REGION
May. General Meeting of the Australian and New Zealand Association for the Advancement of Science. Brisbane, Australia.
(ANZAAS, 10, Martin Place, Sydney, 2000, Australia)

RUBBER EXHIBITION
June 8-12. Int'l Rubber Conference & Exhibition. Harrogate, U.K.
(Richard H. Craven. Plastics & Rubbers Institute, 11 Hobart Place, London, SW1W OHL, U.K.)

WOOD AND PULPING
June 9-12. The "Ekman-days" Int'l Symposium on Wood and Pulping Chemistry. Stockholm, Sweden.
(Dr. P. F. Nelson, Australian Paper Manufacturers Ltd., Research Laboratory, 17, Rex Ave, Alphington, Vic. 3078, Australia)

SURFACE AND COLLOID SCIENCE
July 5-10. 4th Int'l Conference on Surface and Colloid Science. Jerusalem, Israel.
(Prof. A. Silberberg, Dept. of Polymer Chemistry, Weizman Institute of Science, Rehovot, Israel)

MACROMOLECULAR CHEMISTRY
July 6-9. 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chemie, Macromolécuiaire, Tour 44, 1er Etage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France)

CHARACTERIZATION OF POLYMERS
July. 22nd Prague Microsymposium on Characterization of Dynamic & Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlacek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Science Heyrovskeho, N.2 CS- 162 06, Praha 616, Czechoslovakia)

NMR
July 12-17. 5th Int'l Meeting on NMR Spectroscopy. Exeter, U.K.
(U.K. Chemical Society, Burlington House, London, W1V OBN, U.K.)

POLYMER CHARACTERIZATION
July 13-17. Int'l Symposium on Advances in Polymer Characterization. Durham, U.K.
(Dr. W. J. Feast, Chemistry Dept. University of Durham, South Road, Durham, DH1 3LE, U.K.)

PLATINIUM GROUP METALS
July 19-24 Int'l Conference on the Chemistry of Platinium Group Metals. Bristol, U.K.
(Dr. P. L. Gogin, School of Chemistry, The University, Bristol, BS8 1TS, U.K.)

PHARMACOLOGY
July 19-24. 8th Congress of the Int'l Union of Pharmacology. Tokyo, Japan.
(Dr. F. Gross, Dept. of Pharmacology, University of Heidelberg, Im Neuenheimer Feld 366, D - 6900 Heidelberg, Federal Republic of Germany)

ORGANIC SYNTHESIS
July 20-23. 7th Int'l Symposium on Synthesis in Organic Chemistry. Oxford, U.K.
(U.K. Chemical Society, Burlington House, London, W1V OBN, U.K.)

CAROTENOIDS
July 26-31. 6th Int'l Symposium on Carotenoids. Liverpool, U.K.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, P.O. Box 147, Liverpool, L69 3BX, U.K.)

CONFERENCES 1981/82

CHEMICAL EDUCATION
August. 6th Int'l Conference in Chemical Education. Maryland, U.S.A.
(Prof. Marjorie Gardner, Department of Chemistry, University of Maryland, MD, U.S.A.)

ORGANOMETALLIC CHEMISTRY
August 2-6. Int'l Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, CO, U.S.A.
(Prof. J. K. Stille, Dept. of Chemistry, Colorado State University, Fort Collins, CO 80523, U.S.A.)

ORGANOMETALLIC CHEMISTRY
August 9-14. 10th Int'l Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada, N1G 2W1)

IUPAC CONGRESS
August 16-22. 28th IUPAC Congress. Vancouver, Canada.
(Mr. T. H. G. Michael, Executive Director, The Chemical Institute of Canada, 151 Slater St., Ottawa, Ontario, KIP 5H3, Canada)

CRYSTALLOGRAPHY
August 16-25. 12th Int'l Congress of Crystallography. Ottawa, Canada.
(Mr. K. Charbonneau, Executive Secretary, 12th IUCr Congress, National Research Council of Canada, Ottawa, Ontario, KIA OR6, Canada)

ANALYTICAL STUDIES
August 20-21. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford St., London SE1 9NQ, U.K.)

AMERICAN CHEMICAL SOCIETY
August 23-28. ACS Fall Meeting. New York City, U.S.A.
(American Chemical Society, 1155 16th Street, N.W., Washington D.C. 20036, U.S.A.)

EUROANALYSIS
August 23-28. 4th FECS Conference Euroanalysis. Helsinki, Finland.
(Prof. Lauri Niinisto, Department of Chemistry, Helsinki University of Technology, 02150 Espoo 15, Finland)

SOLAR ENERGY
August 24-28. Int'l Solar Energy Congress. Brighton, U.K.
(Prof. David Hall, University of London, Kings College, 69 Half Moon Lane, London SE24 9JF, U.K.)

DRUG RESEARCH
August 25-28. Symposium on the Strategy of Drug Research. Noorduijkerhout, Netherlands.
(Koninklijke Instituut van Ingenieurs, Sectie Chemische Techniek, Prinsessegracht, 23, Den Haag, Netherlands.)

HISTORY OF SCIENCE
Aug. 26-Sept. 3. 16th Int'l Congress of the History of Science. (Bucharest). Bucharest, Romania.
(S. Balan, Romanian Academy of Science, Calea Victoriei 125, Set 1, Bucharest, Romania)

BIOPHYSICS
August. 7th Congress of the Int'l Union of Pure and Applied Biophysics. Mexico City, Mexico.
(Dr. K. Wuthrich. Inst. of Molecular Biology and biophysics, E.T.H. 8049, Zurich, Switzerland)

NONBENZENOID AROMATIC COMPOUNDS
Aug. 30-Sept.4 4th Int'l Symposium on Chemistry of Nonbenzenoid Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Department of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

CLINICAL CHEMISTRY
Aug. 30-Sept.5 11th Int'l Congress of Clinical Chemistry. Vienna, Austria.
(Secretariat, 11th Int'l Congress of Clinical Chemistry, 4th European Congress of Clinical Chemistry, P.O. Box. 35, A - 1095, Wein, Austria)

PHOTOCHEMISTRY
September. 10th Int'l Conference on Photochemistry. Crete, Greece.
(Dr. P. M. Rentzeipis, Bell Laboratories, ID 358, Murray Hill, NJ 07974, U.S.A.)

METALLIC CORROSION
September 6-11. 8th Int'l Congress on Metallic Corrosion. Mainz, F. R. Germany.
(7th Congress of the European Federation of Corrosion, DECHEMA. P.O. Box. 97, 01 46, D - 6000, Frankfurt 97, Federal Republic of Germany)

WATER POLLUTION CONTROL
October 4-10. Water Pollution Control Federation Int'l Convention. Detroit, Michigan, U.S.A.
(R. A. Canham, 3900 Wisconsin Avenue, NW, Washington D.C. 20016, U.S.A.)

CHEMICAL PHYSICS
October 1-7. Int'l Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-b, SU-117334 Moscow, USSR)

CHEMICAL ENGINEERING
October 4-9. Interamerican Congress of Chemical Engineering. Montreal, Canada.
(Canadian Society for Chemical Engineering, 151 Slater St., Suite 906, Ottawa, Ontario K1P 5H3, Canada)

ENVIRONMENTAL POLLUTION
December 18-19. European conference on Environmental Pollution. Frankfurt, Germany.
(Alena Enterprises of Canada, P.O. Box. 1779, Cornwall, Ontario, K6H 5V7, Canada)

1982

COORDINATION CHEMISTRY
Int'l Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. Peck. Institute of Physical Chemistry, Kossuth Lajos University, Debrecen, Hungary)

CHEMISTRY RELATING TO AGRICULTURE
February 7-11. Chemical Research to meet the Worlds expanding Food Needs. (CHEMRAWN II). Manila, Philippines.
(Int'l Rice Research Institute, Manila, Philippines)

UK CHEMICAL CONGRESS
Mar. 30-Apr. 1 Annual Chemical Congress.
(Chemical Society, Burlington House, London W1V OBN, U.K.)

MACROMOLECULES
July 12-16. IUPAC Macromolecular Symposium. Massachusetts, U.S.A.
(James C. W. Chien, Dept. of Polymer Science and Engineering, University of Massachusetts, Amherst, Massachusetts 01003, U.S.A.)

BIOCHEMISTRY
August 15-21. Int'l Congress of Biochemistry. Perth, Australia.
(Australian Academy of Science, P.O. Box 783, Canberra City, ACT. 2601, Australia)

POLYMERIZATION OF HETEROCYCLES
Summer. Int'l Symposium on Polymerization of Small Heterocycles. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, P.O. Box 49, Curie - Skodowskiej 34, PL - 41 800 Zabrze, Poland)

MYCOTOXINS & PHYCOTOXINS
August. 5th Int'l IUPAC Symposium on Mycotoxins & Phycotoxins, Vienna, Austria.
(Prof. P. Krogh, Dept. of Veterinary Microbiology, Purdue University, W. Lafayette IN 47907, U.S.A.)

NATURAL PRODUCTS
August 20-17. 23rd Int'l Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Dr. J. R. Bull, National Chemical Research Laboratory, C.S.I.R. P.O. Box 395, Pretoria 0001, South Africa.

OFF THE PRESS

Recent IUPAC publications

The Teaching of Chemistry—
interaction between
Secondary and Tertiary Levels

Proceedings of the International Conference on Chemical Education, held in Dublin in August 1979, edited by J. E. Gowan and P. E. Childs, are obtainable from the Conference Organizer, P. A. Start, Department of Chemistry, University College, Dublin, Ireland. Orders should be accompanied by a cheque or money order for US-$10 (or UK £5) per copy. Conference participants may obtain their copies for US-$6 (or UK £3).

Frontiers of Bioorganic Chemistry and Molecular Biology

This book is based on a conference dealing with the physicochemical basis of life processes. The conference, the Int. Symposium on Frontiers of Bioorganic Chemistry and Molecular Biology (held 25 Sept.-2 Oct. 1978 in Moscow and Tashkent, USSR), reflected present and future study in a diverse range of topics. The 57 papers dealt with peptides and proteins, nucleic acids, polysaccharides, and other biopolymers; and the study of low molecular regulators—including steroids, alkaloids, antibiotics etc. The latest achievements were discussed in the study of genetic structures and of cellular protein synthesizing systems, of the molecular basis of enzymic catalysis and of bioenergentic processes, as well as essential problems in immunochemistry, nervous transmission, and hormone regulation.

The 474 page volume contains 1364 references, which no doubt posed a formidable task for the editor, S. N. Ananchenko (USSR Academy of Sciences). Due for publication in April, the hardcover volume will be available at a cost of £36 (US $80) from Pergamon Press.

Argon
Volume 4: IUPAC Solubility Data Series

This hardcover reference volume contains (1) experimental solubility data of argon gas in liquids (water, salt solutions, hydrocarbons and organic solvents) as reported in the scientific literature, (2) tables of smoothed mole fraction solubility data for the systems which were studied over a temperature interval, and (3) tables of either tentative or recommended solubility data when two or more laboratories reported solubility data over the same range of temperature and pressure for a system. Users have the option of using the experimental values, either directly or in their own smoothing equations, or of using the smoothed values prepared by the compilers and evaluators.

Editing of the 348 page book was undertaken by H. Lawrence Clever of Emory University (USA). It is expected to be available in April at a price of £50 (US$100).

Future Sources of Organic Raw Materials
(Proceedings of CHEMRAWN I)

IUPAC's initial enterprise in the CHEMRAWN (Chemical Research Applied to World Needs) programme was to convene the first "World Conference on Future Sources of Organic Raw Materials". This international conference attempted to define and set in perspective those factors that will ultimately determine the sources of organic raw materials necessary to support world chemical industries at the end of the century. The various sessions not only dealt with the future life-blood of some of our major industries but inspired and stimulated vast and fertile new fields for those working in the more basic, exploratory areas.

These proceedings are essential reading for policy makers in both government and industry, and for scientists concerned with the need to plan for the future resources.

Papers presented at the conference have been organized into the following sections:
Planning for Future Resources (Availability and Demand Pattern for Fossil Hydrocarbons, and for Renewable Resources).
Advanced Technologies for Coal, Wood and Related Feedstocks.
New Directions in the Production of Renewable Resources.
Conversion and Utilization of Renewable Resources.
Planning for Future Resources.
Advanced Technologies for Coal, Wood and Related Feedstocks.
Future Feedstocks from Petroleum, Oil, Shale and Tar Sands.
New Approaches to the Chemistry of Renewable Resources.

The 612 page hardcover volume contains 52 papers and over 1200 literature references. It is available from Pergamon Press. The price is £22.50 (US$45), with a special price of US$25 for developing countries.

Alkali Metal, Alkaline-earth Metal & Ammonium Halides in Amide Solvents

This volume presents available solubility data of halides and pseudohalides of the alkali metal, alkaline-earth and ammonium ions in the six simple amides: formamide, N-methylformamide N,N-dimethylformamide, acetamide, N-methylacetamide and N,N-dimethylacetamide.

These solvents are of both theoretical and practical interest, primarily because of their ability to dissolve significant quantities of electrolytes. Each solute-solvent system is critically evaluated paying particular attention to (1) the techniques and procedures used in purification, (2) the length of time allowed to ensure saturation and (3) the methods used to detect that equilibrium had been established. Literature references are included to 1979.

This 374 page hardcover volume, the eleventh in the Solubility Data Series, has been edited by Prof. Bruno Scrosati (Univ. of Rome, Italy) and Dr. Colin A. Vincent (Univ. of St. Andrews, Scotland). It is available from Pergamon Press at a price of £50 (US$100).

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and appplied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

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Chemistry International

IUPAC

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CHEMISTRY INTERNATIONAL

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EDITOR: Dr. Martin Gellender
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MANUSCRIPTS

Prospective authors should send an outline of the proposed article to the Editor with a brief letter explaining why the subject might be of wide interest or significance.

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THE EDITOR'S DESK

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Will a rising tide of information conceal what we need to know?

The growing volume of technical knowledge has compelled chemists to rely on microfilm equipment and computer data banks for locating and retrieving chemical information. This recent technology allows access to information with greater depth than was ever possible before. This enormously enhanced capability may encourage chemists to become more and more specialized, as indeed they must to keep pace with all developments in their subject area. Could this be counterproductive—even dangerous?

The danger is pointed out in an article by David Andrews, which appeared in the March 19th edition of the UK newspaper, *The Guardian.* He observes that the communication media that scientists have come to rely on—libraries, computer data banks and specialized journals—are "non-interactive". That is, they can provide information that you *think* you need to know. They cannot tell you of developments in other fields about which you are unaware, but which might have a critical bearing upon your work.

As a specific example, Mr. Andrews refers to the design of irrigation systems in developing countries. To obtain information for the design of such a system, an engineer would refer to his professional journal, textbooks, codes of practice for irrigation systems, weather data and water requirements for local agriculture. He would use this information to design and build the irrigation system. But, as Mr. Andrews points out, none of these sources would tell the engineer that his irrigation plans could create conditions favourable for parasitic worms causing the debilitating disease of Bilharzia (shistosomiasis). In fact, irrigation projects are believed to be largely responsible for the disturbing worldwide proliferation of this chronic disease to an estimated *600 million* people.

Mr. Andrews asserts that "The relevant facts about Bilharzia were known to the medical profession 50 years ago. Yet, engineers did not know them, and until quite recently designed irrigation systems such that simple, inexpensive Bilharzia control methods could not be applied. . ."

"Why did crucial information take 50 years to penetrate through to the civil engineers? Quite simply, it was because they were the unwitting victims of the relevance paradox—they did not know that they needed to know it. Their non-interactive information systems did not tell them that they needed to find out about Bilharzia."

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The paradox is a two-way problem. People who need certain information don't know it exists, and people who have the information are unaware of its importance to others. Mr. Andrews cites the development of a particular laser at a Canadian university and how information of its construction was disseminated to other research groups. The group that developed the laser published all the information that they thought was necessary for others to construct an operational laser. However, attempts by other researchers were successful only after discussions with the original developers. Even they did not realize which information was essential for others to build the apparatus. It is perhaps even more important that developers of a new technique realize that others, outside their field of specialization, may be able to benefit.

Mr. Andrews stresses that non-interactive information media cannot replace informal contacts among individuals in different specializations. He points out that coffee breaks or golf club meetings can serve a vital function, whose importance is often overlooked, in transferring information from one specialization to another.

What can we do, as individual chemists, to augment communication outside our respective areas of expertise? The answer is clearly not to drink more coffee -although drinking coffee with *more people* might certainly help. To this end, Dave Andrews recommends that specialists working in different subject areas join together to form groups of 50 - 100 people, and meet periodically to discuss common aspects of their work. Mr. Andrews presents specific proposals for the formation of such groups in his 14-page report *Communication & Integration in the Agriculture, Water, Waste & Energy Sectors* (Report ERG 033, available from the Energy Research Group, Open University, Walton Hall, Milton Keynes MK7 6AA, UK).

In our day-to-day work, perhaps we should be more receptive to information that might not initially appear directly related to our own work. And perhaps we should publish our major findings more widely and with greater clarity so as to be seen and understood by specialists in other technical areas who don't know what we do, and don't know that they should.

To err is human . . .

Prof. M. L. McGlashan (of University College London) informed us of "the misleading. . hoax about 'Monsieur Litre' perpretrated in *Chemistry International* 1980, No. 1, p. 32". Stating that the story is completely untrue and probably originated as a joke, he wrote to say, "It is almost unbelievable that so many otherwise reputable scientists should be so gullible as to swallow such an article, but I am sick and tired of pointing out to the convinced that it was a spoof. What it must have done to less sophisticated scientists!"

Among these less sophisticated scientists was the editor of this magazine. Failing to detect the intended humour of the story, he unwittingly published it as a legitimate article.

Considerable efforts are made to ensure that information presented in *Chemistry International* is accurate. However, unless there is cause for suspicion, it is assumed that communications from established scientists are sincere. During routine checking of this article, no one informed the editor that the biography of M. Litre was a spoof. The editor extends his apologies for confusion which arose from publication of this article.

Natural products are viewed as lethal poisons & carcinogens

"No other group of chemicals has caused such a high number of deaths in the past", noted Dr. Christian Schlatter (of the Swiss Federal Institute of Technology). Other conclusions presented by chemists and biochemists at the conference were equally startling. Dr. Edward Schantz (University of Wisconsin—Madison) stated that "The tremendous fish kills . . . along the Florida coast have caused severe environmental problems due to the decaying fish and polluted waters in these areas". The subject on which they spoke was not mercury polution, DDT, Dioxin, chemical warfare agents or air pollution. They were discussing a source of disease and death which has undoubtedly plagued mankind for many thousands of years, but which has only recently been recognized with modern chemical analysis techniques. They were discussing *naturally-occurring* food poisons at the 4th International IUPAC Symposium on Mycotoxins and Phycotoxins.

The conference focussed on the two main types of extremely poisonous compounds: those produced by mold growing on improperly-stored foodstuffs (mycotoxins), and those produced by a few species of blue-green alga and dinoflagellates which lead to contamination of seafood (phycotoxins).

In presenting an overview of the *Past and Present in Mycotoxin Toxicology Research,* Dr. Schlatter pointed out that "most probably even now, victims of mycotoxins, especially among domestic animals, are much more frequent than deaths due to other chemicals such as pesticides, industrial or environmental chemicals". In the Middle Ages, thousands of people suffered from ergotism, an illness caused by the consumption of mycotoxin-contaminated rye. The relationship between the consumption of contaminated rye bread and the disease was discovered as early as 1673, but the disease continued to occur regularly for at least another century.

Another example of mycotoxicosis is the toxic yellow rice disease encountered especially after World War II in Japan. Since the toxicity of yellow rice was well-known, such contaminated rice was used for industrial production of alcohol or was blended with other foodstuffs, so no human fatalities occurred. When contaminated rice was accidentally fed to chickens, 3 000 died of acute liver damage. In fact, Dr. Schlatter indicates that the consumption of mycotoxin-contaminated rice may be related to a high incidence of liver disease and liver cancer in certain areas of Asia.

It was not until after the early 1960's that mycotoxins came under intensive study. Interest was no doubt precipitated by the mysterious deaths of thousands of turkeys during a massive outbreak of 'Turkey X Disease' in England in 1961. The outbreak was later traced to the animal feed, which contained peanut meal contaminated with metabolic products of the mold *Aspergillus flavus.* The toxic compounds, later named 'aflatoxins' were identifed and subsequently were also found in a range of nuts and grains which had been improperly stored. Failure to dry the material soon after harvest and maintain dry conditions during storage was discovered to be the single most important factor favouring growth of the mold and the production of aflatoxins.

Much of the toxicity of aflatoxins remains after normal processing and cooking of food. The severity of aflatoxin poisoning varies with the species of animal, age, sex and state of nutrition. In general, young animals are more vulnerable. Turkeys, ducklings, chicken and trout are highly susceptible, and in fact, day-old ducklings are used for bioassays of aflatoxins.

The quality of animal feed is generally lower than foodstuffs for human consumption. Consequently, acute poisoning from aflatoxin-contaminated feed could be a serious problem in animals (in test rats for example, a single dose of 4.5 mg/kg of body weight causes fatal liver damage in half the animals). The major concern for human health, however, is the effect of chronic low-level exposure. Circumstantial evidence has accumulated to implicate aflatoxins as a cause of liver cancer in humans. There appears to be a relationship between high levels of aflatoxins in the diet and the incidence of malignancies. Among people in most parts of Africa and the Far East, primary liver cancer is one of the most common forms of malignancy. In experiments with rats, extended feeding of a diet containing as little as 15 parts-per-billion has resulted in liver cancer.

It is not surprising that aflatoxins are now the most intensely studied of all mycotoxins. Preliminary screening tests have been performed on most known mycotoxins, and none of these appears to have the extremely high cancer-causing potency of aflatoxins. Some countries undertake routine testing of

A highly magnified view of a commonly underrated threat: the aflatoxin-producing fungus *Aspergillus flavus*. The fungus, shown at 2500X magnification, produces the deadly aflatoxin poison during growth on food that is improperly dried and stored. (*Photograph taken by D. Metzger of the University of Zurich, and provided courtesy of Dr. Christian Schlatter.*)

agricultural foodstuffs for mycotoxins, but many developing countries are unable to afford routine testing, or the destruction of foodstuffs contaminated above acceptable levels.

An alternative strategy is to develop chemical treatments which destroy mycotoxins in food. Several decontamination processes have been developed and are now being evaluated. Ammonia gas is used for detoxifying cotton seed cake and cotton seed at two plants in the United States, and two others in Senegal and Sudan use an ammoniation process developed in France. No difference has been observed between the nutritional value of treated and untreated product, and the treatment adds only about 3% to the cost of the product. This decontamination procedure is being considered for use in France, reports Dr. Mongi Jemmali (in his paper *Decontamination and Detoxification of Mycotoxins),* and temporary approval has been granted by the US Food & Drug Agency.

Other processes are being studied for the treatment of contaminated corn and oilseeds. One uses calcium hydroxide and methylamine to destroy aflatoxins, attacking the molecule's lactone ring much the same as does ammonia. Another process, using hydrogen peroxide to treat groundmeal protein, is used on a commercial scale in India to treat oilseed cake for human consumption.

Dr. Jemmali urges that development of decontamination methods should be given priority. Despite the greater emphasis that he feels is needed on research in this area, he concludes his paper with a reassuring thought. "Very few mycotoxins are natural contaminants (produced under natural conditions), compared to the numerous toxic metabolites produced under artificial conditions." This, along with the reduction in mycotoxin concentration during normal processing, explains why mankind has not been decimated by mycotoxin poisoning before their existence was even suspected.

Poisonous algae account for outbreaks of seafood poisoning

The discovery of phycotoxins as a cause of seafood poisoning parallels the detection of mycotoxins in contaminated grains. The first cases of seafood poisoning attributed to phycotoxins occurred during the summer of 1927, when people who had eaten sea mussels collected near San Francisco became seriously ill (some died). Investigators noted that a particular alga (a dinoflagellate) was present in the water where the mussels were feeding. Subsequent experiments showed that the mussels, normally quite safe to eat, became poisonous during the 1 - 3 weeks period when the alga bloomed. Afterwards, the poisonous dinoflagellate died out, non-poisonous ones bloomed as food for the mussels, and the mussels soon destroyed or excreted the poison. It was soon deduced that the dinoflagellate

Gonyaulax catenella accounted for shellfish poisoning along the Pacific Coast of North America and Japan, and along the southern coast of Chile and South Africa.

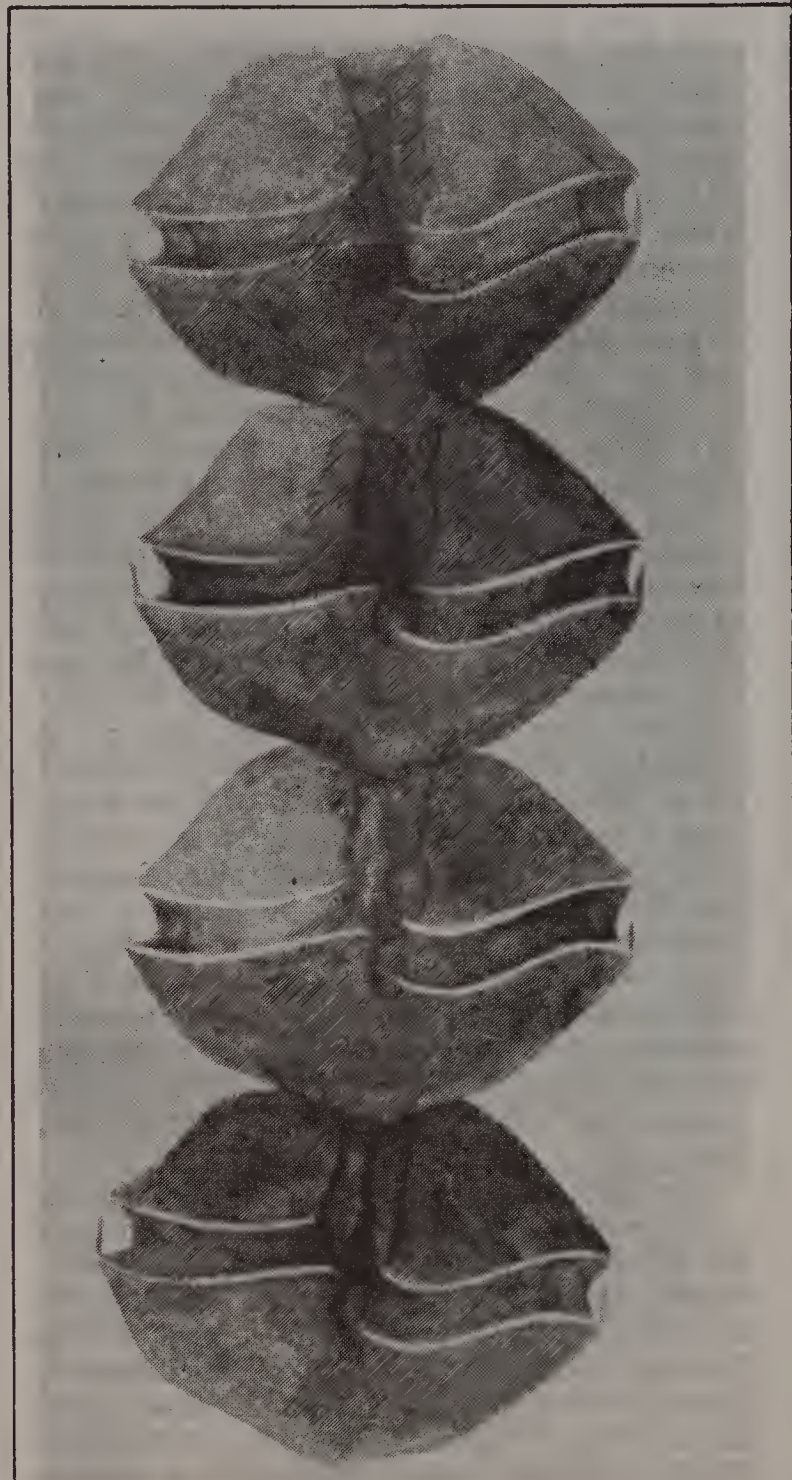
Soon, other algal species that caused shellfish to become poisonous were discovered. The dinoflagellate *Gonyaulax tamerenis* was identified as the cause of paralytic poisoning from scallops in the Bay of Fundy (Canada) in clams and mussels along the North Atlantic coast of the USA, and in shellfish poisoning along the northeast coast of England. The chemical structures of the paralytic poisons produced by *G. catenella* and *G. tamarensis* have been determined by investigators at the University of Wisconsin. These poisons are substituted tetrahydropurines.

Another dinoflagellate, *Gymnodinium breve,* produces a compound that has killed large numbers of fish and caused severe environmental problems in the Gulf of Mexico, while another dinoflagellate is believed responsible for the human disease called ciguatera, the largest public health problem involving seafood poisoning.

About a dozen dinoflagellate species are known to produce poisons, but these constitute only a very small fraction of the approximately 1200 species of dinoflagellate that are known. Different strains of dinoflagellates—as well as different species—produce distinctly different toxins. Some are low-molecular-weight compounds which exert a rapid paralytic effect on the nervous system. Others are slow-acting protein fragments which are toxic to the liver and nervous system. Some dinoflagellate strains can produce more than one type of toxin.

Studies of phycotoxins are especially important at this time, as freshwater blue-green algae are potentially an excellent source of food. Algae grow rapidly, can be cultured on waste nutrient sources, have a high protein content and are quite digestible. However, a possible danger of using blue-green algae as food for animal livestock or man, as pointed out by Paul Gorham and Wayne Carmichael (of the University of Alberta, Canada), is that toxic strains of several species of blue-green algae exist which are indistinquishable from the non-toxic strains.

In the past, shellfish poisoning was a local health problem in areas where poisonous dinoflagellates bloomed and people collected the shellfish for food. However, with present commercial harvesting and shipment of shellfish and fish to many parts of the world, the food poisoning problem could acquire global significance. The potential danger was underlined by Dr. Edward Schantz. He points out that phycotoxins are difficult to control because of the unpredictable and sporadic occurrence of the organisms producing them. Shellfish usually show no visible indication if they are contaminated. A person collecting shellfish for food has no way of distinguishing poisonous and edible shellfish, except by observing the onset of sickness in persons or animals who have consumed the shellfish. There is no known antidote for paralytic shellfish poisoning except for maintaining breathing through artificial respiration. One phycotoxin, saxitoxin (one of the poisonous compounds produced by *G. catenella*), exhibits such strong and specific action in blocking the passage of sodium ions through nerve cell membranes, that it has become a valuable tool for medical research on nerve transmission.



One of the deadliest creatures of the sea is the alga *Gonyaulax catenella*. It produces highly poisonous phycotoxins, which contaminate shellfish which feed upon it. Consumption of these shellfish by fish, or harvest for human consumption, can have lethal consequences.

Cells of *G. catenella* usually form chains of 4 or 8 cells in a row, as shown in this photograph of a laboratory culture. The cells are about 60 microns in diameter. (*Photograph courtesy of Prof. Edward Shantz.*)

Chemistry and food supplies are focus of a major IUPAC undertaking

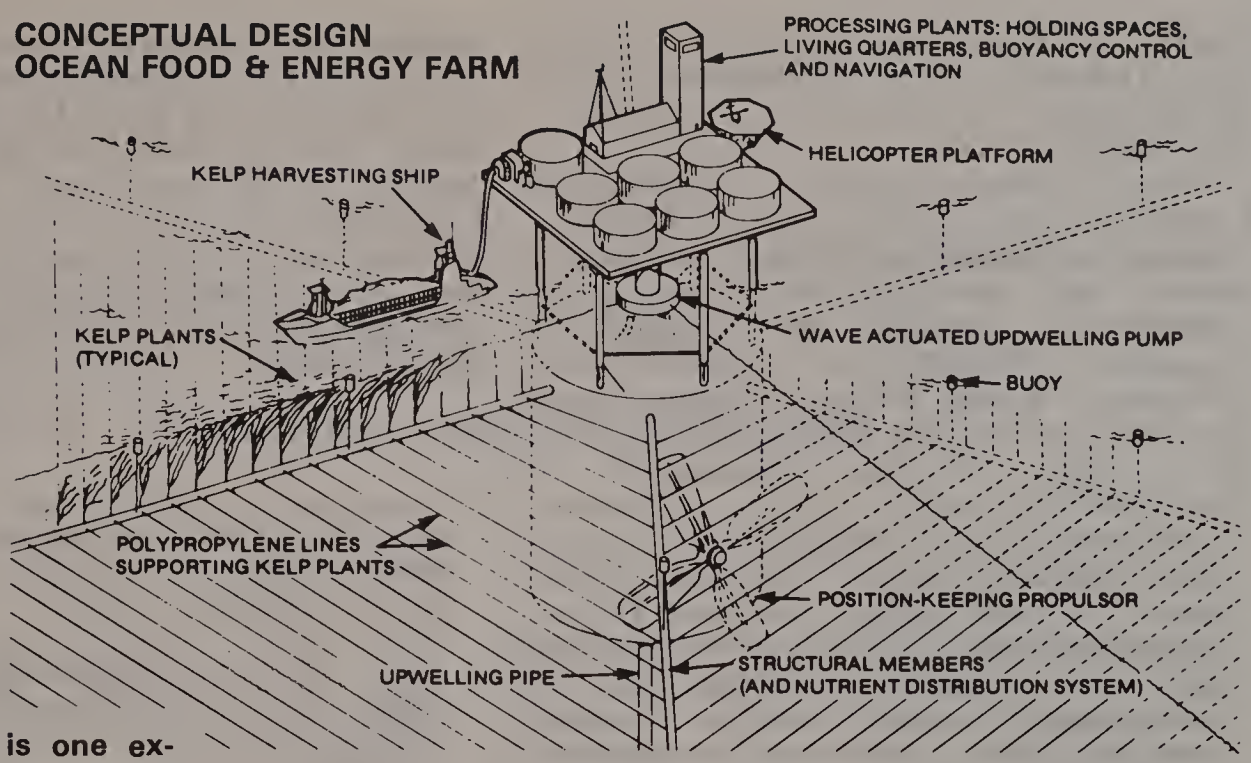
Ever since the sucessful convening of the first conference dealing with *Chemical Research Applied to World Needs* (CHEMRAWN), considerable attention has focussed on new topics which could be encompassed within the CHEMRAWN theme. The first conference, which in July 1978 attracted 800 experts from universities, industry and governments of 48 countries, dealt with "Future Sources of Organic Raw Materials". Insights, predictions and conclusions expressed at that conference have gained even greater significance, influenced by international events of the last two years. Presentations made at the conference remain as a base of information for decision makers in government, industry and university research laboratories. Major conclusions which emerge at the first CHEMRAWN conference have been published as a short summary volume[1] and as a full proceedings[2].

Soon after the outstanding success of CHEMRAWN I, the CHEMRAWN Committee of the International Union of Pure & Applied Chemistry (IUPAC) began to consider other areas of world needs for which chemistry has the opportunity and obligation to find answers. They recognize that the answers alone—without proper political and social action—are meaningless, and that it is vital for these elements to work closely with chemical science and technology to extend the benefits of science and technology to all the Earth's people.

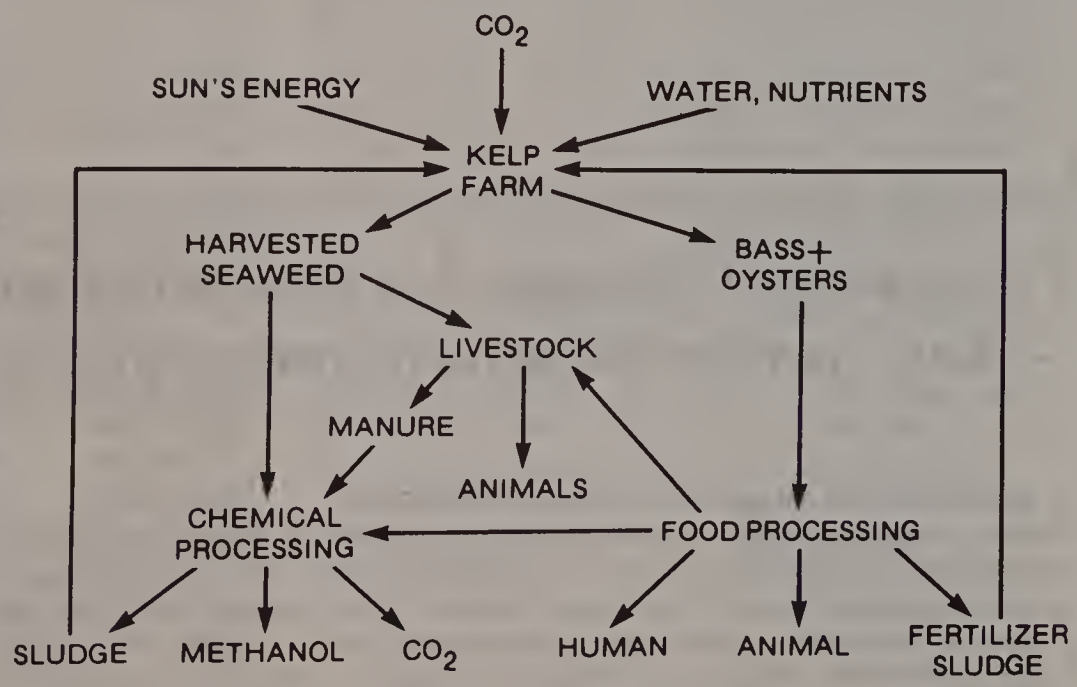
For further action, the CHEMRAWN group considered various world problems which could be solved or ameliorated by application of science and technology. Future CHEMRAWN activities, they feel, should be aimed at high priority needs of global or multinational interest. Other criteria should be met as well, and among them: chemistry must be a dominant theme, although it must be possible to treat the subject as a multidisciplinary system: the topic must have sufficient long-range interest to become of increasing importance to society and to the chemical community; it must achieve a balance between the needs of developed and developing countries; and CHEMRAWN programs should establish IUPAC as the principal sponsor correlating with and strengthening programs in other IUPAC Divisions.

The next subject area onto which the Committee has crystallized its attention is chemistry and agriculture. CHEMRAWN II will be concerned with the application of chemical research and modern agriculture methods to help the billion people, nearly one-fourth of the Earth's population, who are underfed and undernourished. The official title of the meeting has now been established as the *International Conference on Chemistry and World Food Supplies,* and the dates that the conference will be held have been set for 9 - 12 February 1982. Its convening in Manila (the Philippines) reflects the strong participation expected from leaders and technical experts from

CHEMRAWN committee chairman Bryant Rossiter would like to see the CHEMRAWN program serve as an international, non-governmental source of advice for the benefit of governments and international agencies. He believes that proposed new initiatives of the CHEMRAWN program, such as helping to establish central data banks within existing United Nations agencies "could provide IUPAC with a new and significant role in the world scientific arena".



Ocean farming is one example of how chemical research might help meet world needs for organic raw materials and food. Seaweed has been a source of food for centuries, but with advanced techniques, marine plants could be grown on a much more extensive scale and provide a wider range of chemical products. The capability of the ocean surface to provide an inexhaustible supply of chemicals and food was discussed by Dr. V. J. Chapman at CHEMRAWN I (see *Future Sources of Organic Raw Materials,* p.551) and could prove a fertile area for further discussion at CHEMRAWN II.



An ocean farm could achieve a copious harvest of kelp by providing mineral salts from deep (300 m) water, physical support for growth, and sunlight. Based on current experiments, a farm covering 4 km^2 of ocean surface (such as the one depicted here) could produce 6.4 × 10^6 m^3 of synthetic natural gas, 1800 tons of Kelp Bass, 360 tons of oysters and 9600 tons of animal feed.

developing countries, as well as active participation expected from technologically advanced nations. The Philippines is situated in an area of the world where nutritional needs are acute, yet where great progress has been demonstrated.

The conference will serve as an international, non-governmental forum focussing on key issues, significant new research findings, and the shaping of plans and programs. Among other topics, the conference will deal with fertilizers, pesticides, crop hormones; food preservation, processing and storage; residues, toxins, micro-nutrients and food quality. Specific recommendations for action will be derived from the conference and compiled into a summary report to be sent to decision makers around the world.

In addition to IUPAC sponsorship, the conference will be co-sponsored by the International Rice Research Institute (located in the Philippines). General Chairman of the conference is the world-renowned agricultural expert Dr. Nyle C. Brady. Program chairman is Dr. Norman E. Borlaug of the International Maize and Wheat Improvement Research Center (of Mexico), the only chemist to have won a Nobel prize in agricultural research. Dr. Charles Dennison (Executive Director of the US Council on Science and Technology for Development) will serve as General Secretary and Finance Committee Chairman, assisted by World Bank Vice-president Dr. W. David Hopper. Additional information about the *International Conference on Chemistry and World Food Supplies* may be obtained from the Conference Secretariat located at the International Rice Research Institute (P.O. Box 933, Manila,

the Philippines) or from the Council on Science and Technology for Development (2010 Massachusetts Avenue N.W., Washington D.C. 20036, USA).

On which other topics does the CHEMRAWN Committee plan to focus the attention of chemical researchers and government leaders? Several topics have been selected for further consideration, according to CHEMRAWN Committee Chairman Dr. Bryant Rossiter (Director of Kodak Research Laboratories in the USA). Dr. Rossiter, who provided much of the energy for the organization of CHEMRAWN I and much of the enthusiasm for the germination of CHEMRAWN II, cites a world conference on the "Chemistry of the Oceans", a joint project (with the IUPAC Clinical Chemistry Division) on the "Chemical Basis of Carcinogenesis, Mutagenesis and Teratogenesis", a conference on chemical aspects of water quality and conservation (especially as it applies to the arid regions of the Earth), and an updated look at "Future Sources of Organic Raw Materials" sometime during 1983 - 85. However, Dr. Rossiter emphasizes in the most recent report of the CHEMRAWN Committee that these projects presently are only under consideration. Meanwhile, the CHEMRAWN group is receptive to new ideas about where chemistry can be applied to world needs.

1. *Resources of Organic Matter for the Future; Perspectives & Recommendations, L. E. St-Pierre (editor), 184 pages, 1979, Multiscience Publications Ltd (Montreal, Canada).*

2. *Future Sources of Organic Raw Materials, 612 pages, 1980, Pergamon Press, Hardcover volume US$45 (special prices of US$25 for developing countries).*

Closer ties foreseen for chemical societies — but not an international group

A proposal to create an International Chemical Society with individual members has undergone several major setbacks, and appears unlikely to gain acceptance in the forseeable future. The proposal was one of the topics discussed at a meeting of Chemical Society Presidents held in Washington, D.C. (USA) last September. Subsequent to that meeting, the American Chemical Society conducted a poll of their own members, of which a majority voiced opposition to the proposal.

So too did many of the Presidents of National Chemical Societies oppose the plan, and this sentiment was crystallized by a letter written by Dr. Alfred Spinks (President of the UK Chemical Society) and Prof. Richard Norman (President, Royal Institute of Chemistry in the UK) and sent to 46 chemical society presidents. Of the 24 presidents who responded, 22 agreed to co-sign the letter.

Secretary of the Royal Institute of Chemistry, Dr. Eric Parker informed *Chemistry International* that this response provides "a fairly clear indication of world opinion". He believes that the other Presidents have not yet replied because they are awaiting authority from their Boards or Councils, which meet only infrequently.

The letter to the Chemical Society Presidents states that an International Chemical Society "would cut across existing national societies and would inevitably lead to greater expense and dilution of effort".

"We believe", the letter continues, "that international collaboration would be better served by building on existing institutions and, in particular, on the existing national chemical societies and on federations of these societies. There are already federations in Europe, Asia and Latin America (the Federation of European Chemical Societies, the newly-formed Federation of Asian Chemical Societies, and the Latin American Federation of Chemical Associations) and there is a Union of Arab Chemical Societies and an Association of Faculties of Science of African Universities. It seems to us that a framework could easily and economically be developed to link together these federations and similar groupings, provided that the appropriate safeguards were devised so as not to exclude societies which are not presently in any such grouping. It is possible that such a framework might be formed through IUPAC."

To investigate how IUPAC might in future involve more of the world's chemists in its activities, a special five-member Subcommittee was formed at the last IUPAC General Assembly. The group will investigate various proposals and report their findings to the 1981 IUPAC General Assembly. In the meantime, the Subcommittee welcomes suggestions. Comments can be sent to the chairman, Dr. T. S. West at the Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen AB9 2QJ, U.K.

Extensive use of vaccines is vital for effective, low-cost health services

As a means of combating deadly and debilitating disease, vaccines are—or could be—the most effective and lowest cost method. At the conference on "Pharmaceuticals for Developing Countries", Dr. William Foege (Director of the Center for Disease Control in the USA) pointed out that one-fifth of present deaths among children less than five years old in developing countries could be prevented by *currently-available* vaccines. From four diseases alone—measles, tetanus, pertussis and poliomyelitis—there are an estimated 2.6 million deaths per year, even though effective vaccines are available. Furthermore, the development of vaccines against malaria, schistosomiasis, dengue and hepatitis B could have enormous impact on saving lives and improving the health of much of the world's population.

Two major problems crystallized into view at the conference, sponsored by the US National Academy of Sciences in January 1979*. First, how can developing countries obtain *presently-available* vaccines of high quality and administer them effectively to the individuals who most need their protection? And secondly, how can research-oriented drug companies be encouraged to develop *new vaccines* for diseases prevalent in the developing world, although these countries cannot afford to purchase large quantities and may not even offer patent protection for new products?

Clearly, part of the answers to both problems will be for developing countries to help themselves. Egypt, for example, manufactures 85% of its own pharmaceutical requirements. Experience in Egypt, noted Dr. Abdou M. Sallam (chairman, Pan Arab Pharmaceutical Company, ACDIMA) has shown that local manufacture of a previously imported drug saves about two-thirds of the currency paid to import it as a finished product. On the whole, the Arab world manufactures 44% of its consumption, while Africa produces less than 10% of its scant pharmaceutical usage.

Indigenous production of vaccines is not necessarily the best method, or even a reasonable course, for most developing countries. Vaccines and pharmaceuticals are only one component of the health system in any country, and many developing countries lack the medical personnel, facilities or distribution system to ensure that vaccines are made available to people who need them. All too often in the past, innoculation programs have been ineffective because vaccines lost potency during storage without refrigeration, were not distributed to people in remote areas, or were not provided to individuals who were most susceptible to the disease (often, young children).

Countries which have no experience in handling and testing pharmaceuticals would be ill-advised to undertake the production of vaccines. Although the World Health Organization assists in transferring this technology (they have written manuals for the production of diphtheria, tetanus and pertussis vaccines), they advise developing countries *not* to consider vaccine production until they have developed their basic technical capabilities. To do this, a three-step program was advocated by Dr. Frank Perkins, Chief of the Biologicals Unit of WHO. The first step, the importance of which is often underestimated, is to create a facility to monitor the quality of (imported or locally-produced) vaccines. Only after this capability has been achieved, should the next step be undertaken: establishing a vaccine blending, filling and packaging facility. Such a national facility would allow vaccine to be imported as (relatively cheap) bulk concentrate, and then to be diluted, blended, loaded into containers and labelled. These procedures are time-consuming and expensive in developed countries, but could be done with local labor and technology in the Third World, permitting labels to be printed in local languages. Dr. Perkin believes that multinational pharmaceutical companies would be most willing to help extend this capability to developing nations, but would be most hesitant to transfer detailed knowledge of vaccine production. The potency of vaccines, or even their safety, can suffer if the manufacturing process is not duplicated with meticulous care, and that might be very difficult in view of limited technological and economic resources in many developing countries.

Furthermore, pharmaceutical companies are concerned that local production of pharmaceuticals will be unfair competition, driving prices down before research and development

Diluting, blending, packaging and labelling of pharmaceuticals are labour-intensive procedures. Above, workers at a Swiss company package rehydration fluid for treatment of cholera. Such operations could be performed to a large degree in the Third world, utilizing local manpower. Experience in handling and testing pharmaceuticals could then provide a technological base for the manufacture of vaccines.

Once available, vaccines must be stored properly and distributed rapidly to local health centres. The last step in the health delivery system is immunization, which can be done rapidly and efficiently with a jet injector. As many as 250 people can be vaccinated in one hour by a two-man health team.

On a global scale, vaccines are probably the most cost-effective drugs. To vaccinate a child against common deadly diseases costs an estimated US$1.90, yet 80 million children are born each year who do not benefit from vaccination programmes. (*Photos courtesy of the World Health Organization*).

costs can be recovered. Most new drugs—once they are discovered, developed and tested—can be copied at minimal expense by any company experienced in drug manufacture. Even large companies are hesitant to undertake costly projects to develop and test new drugs unless they are confident that their new products will have adequate patent protection.

Protection of patent rights is thus an important consideration if pharmaceutical companies are to be encouraged to perform research on diseases endemic to developing countries. Speaking for Farbwerke Hoechst AG, Max Tiefenbacher Esq. noted that "It has become fashionable in Third World countries to attack patent practices of the multinational drug procedures. . .The patent system, it is charged, makes possible an alleged overpricing of drugs by preventing emergence of local competitors. . . Although these charges have been refuted time and again, developing nations have systematically undermined patent protection for pharmaceuticals". Dr. Tiefenbacher contends that "patents in the Third World countries have—for all practical purposes—become an illusion". Only two countries in Africa, and none in Asia, provide patent protection that he feels is satisfactory. In stark contrast to the weakening of patent rights in the developing

Workshop on Vaccine production

The Food & Agriculture Organization (of the United Nations) is planning a Workshop on Vaccine Production, to be held 6 October - 21 November 1980 in Kuala Lumpur. Additional information can be obtained from the Conference Programming Section, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

world, industrial nations have been strengthening patent protection for pharmaceuticals.

How can technology for pharmaceutical manufacture be assimilated rapidly into the Third World, while at the same time, encouraging development of new drugs? One suggestion was offered by Dr. Sallam. He urged that an international organization, such as WHO, UNIDO (United Nations Industrial Development Organization) or a new "International Bank of Health" be created to raise funds for world ownership of critically-needed technology. The technology to make vaccines and other essential pharmaceuticals would be made available to developing nations at a cost adjusted to each country's purchasing power. He estimated that a revolving fund of perhaps US$50 - 100 million would be enough to purchase the essential technology. World ownership may be a new idea when applied to pharmaceuticals, but it is already well established in other areas. UNESCO already regards temples, monuments, historic buildings and other treasures as part of the human heritage. Perhaps, he feels, adequate health care should be part of that heritage.

**The 430 page conference proceedings "Pharmaceuticals for Developing Countries" may be purchased for US$13.50 from the Office of Publications, National Academy of Sciences, 2101 Constitution Avenue NW, Washington D.C. 20418 USA.*

RECENT REPORTS

A Collaborative Study on the Melt Rheology of a Styrene - Butadiene - Styrene block Copolymer. *Pure & Appl. Chem,* 52, No. 5 (May 1980)

Electrochemical Characteristics of Trifluoromethanesulfonic Acid and its Salts in Non-aqueous Solvents. By Taitiro Fujinaga and Ikko Sakamoto, *Pure & Appl. Chem,* 52, No. 5 (May 1980)

Photochemical engines could produce power directly from sunlight

With more and more interest in developing alternative energy sources, photochemists are looking skywards to the sun. Preliminary experiments indicate great potential for sunlight-powered production of hydrogen and other gaseous fuels, or artificially enhanced production of cellulose by photosynthetic plants. One area that has been virtually ignored is the *direct photochemical conversion* of sunlight to mechanical power. But on October 14th, 1978, Drs Makato Tanaka and Shigeru Yanagihara undertook a test run of the world's first photochemical engine. When they exposed their device to sunlight, it began rotating by itself and achieved a continuous running speed of about 12 revolutions per minute.

The device is a true photochemical engine. It derives its power output from chemical reactions driven by ultraviolet radiation in sunlight, and not simply solar heat energy. This was clearly demonstrated by the two Japanese scientists, working in the Mechanical Engineering Laboratory at the Tanuba Research Center in Ibaraki-ken. They noted that the engine stopped rotating when they placed an ultraviolet cut-off filter in front of the engine.

Drs. Tanaka and Yanagihara chose nitrogen dioxide as a working fluid for their photochemical engine. Nitrogen dioxide gas strongly absorbs near-ultraviolet radiation and dissociates into nitrogen monoxide (NO) and oxygen atoms. These initial products undergo a sequence of reactions forming O_2 and O_3. The important consequence is that the pressure of the gas increases while it is irradiated with sunlight. The reactions are ultimately reversible: NO_2 reforms and the pressure drops to its original value when the sunlight is blocked.

The NO_2 working fluid is sealed into 3 reaction chambers, each fitted with an expandable piston linked to a central crankshaft. Only one reaction chamber is exposed to sunlight at any one time. As NO_2 dissociates in the exposed chamber, the pressure increases—driving the piston, and rotating the entire engine assembly around the central crankshaft. This rotation brings the next reaction chamber into the position exposed to sunlight. Meanwhile, NO_2 reforms in the previously-exposed chamber, and the pressure there falls to its initial value.

The engine is still at a primitive stage of development, but the two inventors believe that advanced versions could provide power for space satellites and even compete against photocells for general applications on Earth. To do so, the photochemical engine will probably need a working fluid which absorbs a greater fraction of the solar energy spectrum. Ultraviolet radiation in sunlight only has a power density of about 10 milliwatts/cm^2. Considerably higher power output might be attainable in devices which utilize visible and infrared radiation, as well as ultraviolet.

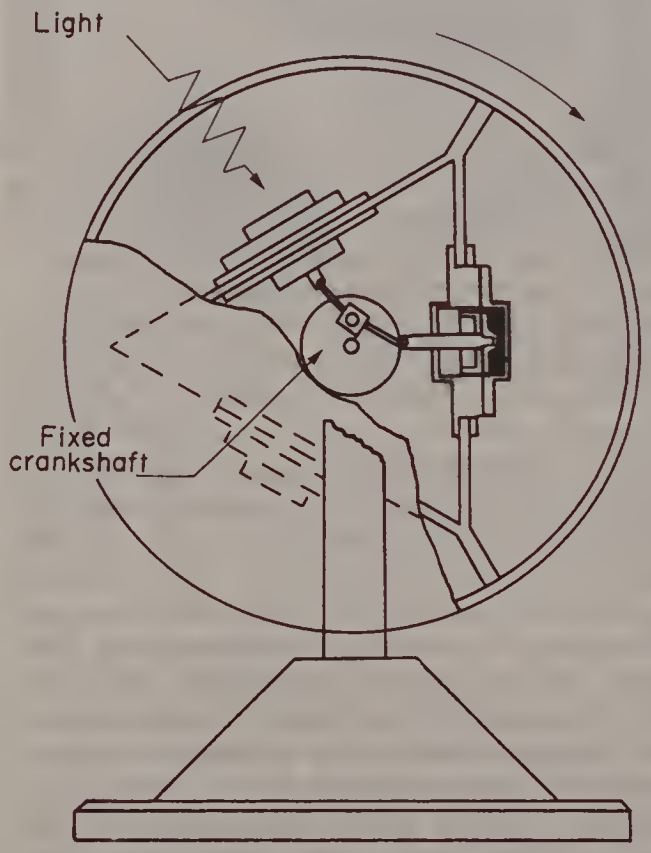
If photochemical engines are to be adapted for practical applications, advanced designs must attain at least the same efficiency as

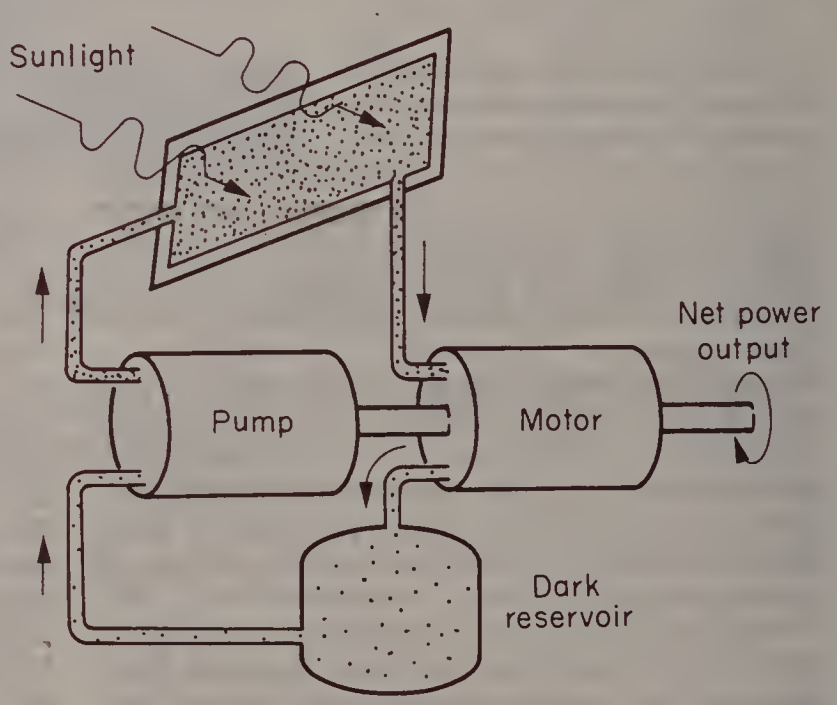
engines which utilize solar heat. Nearly all radiation in the solar spectrum can be absorbed and converted to heat by specially-coated metal panels. Heat can then be extracted from the solar panel by circulating fluid, and the low-grade heat used to drive a heat engine.

Simple heat engines have been built which operate on low-grade heat (about 50° above ambient temperature). These engines utilize phase transitions occurring in solid materials or evaporation of a volatile liquid (ammonia or fluorochlorocarbon). Especially promising are nickel-titanium alloys (nitinol). Nitinol is a pliable material that can be bent to any shape, but reverts to its original 'programmed' shape when heated above its transition temperature. Other materials exhibit such shape-memory effects to a lesser degree, and even rubber bands have been utilized in small operating engines.

The first large-scale power plant utilizing low-grade heat began operating in October 1979 using 98°C cooling water from a steel converter of Sumitomo Metal Industries in Japan. The company is studying the feasibility of building additional generating plants utilizing waste heat from other furnaces and from smokestacks. The same technology might prove well-suited for power production from solar heat. Whatever the source of heat, circulating hot water is used to vaporize a fluorochlorocarbon liquid (Freon 11). The pressurized vapour expands as it drives the blades of a gas turbine. The freon fluid then enters a condenser, where it returns to the liquid state and dissipates its remaining heat content to the environment. A major factor limiting the power output of the gas turbine (and restricting the heat-to-power conversion efficiency to a theoretical maximum of about 20%) is the ambient temperature. To cope with reduced output in summer, Sumitomo Industries plans to use relatively cold seawater for cooling the plant condenser.

All *heat* engines are subject to an inherent limitation on their efficiency, determined by the temperature difference between the heat source and the ambient temperature. Thus, while a simple solar panel can convert virtually all incident solar radiation to low-grade heat, only a small fraction can be converted to mechanical power by a heat engine. By contrast, the opposite limitations might apply to *photochemical* engines. While they utilize only a segment (ultraviolet and/or visible radiation) of the solar spectrum, one would expect that they are not subject to the ultimate efficiency limitation imposed on heat engines.





The first operating photochemical engine had a simple design (left) in which NO_2 working fluid was sealed into 3 rotating reaction chambers. One chamber is irradiated with sunlight, causing the NO_2 gas to expand against a piston connected to a fixed crankshaft. The increased pressure in the reaction chamber is thus converted into a rotational torque.

More advanced photochemical power systems might utilize stationary solar collector panels, as in this configuration envisaged by the editor (right). Gaseous NO_2 (or other working fluid) would be pumped from a dark reservoir into the irradiated panels. There, photochemical decomposition would cause a net increase in the number of gas molecules and a higher pressure. Irradiated gas would then be expanded in a motor. It would seem that the power produced by the motor would be greater than that required to pump the gas into the solar panel, since the irradiated gas would have a greater molar quantity.

An active student role is key component of a novel teaching approach

Can learning be a more active process than sitting passively in lectures? Recalling their own experiences of dull lectures at medical school, Dr. P. L. Schwartz and his colleagues at the University of Otago Medical School in New Zealand ventured to find out. They developed a Clinical Biochemistry Course utilizing some unusual teaching methods—and perhaps more important—encompassing an unusual attitude towards how teachers should relate to their students.

The situation originally faced by clinical biochemistry lecturers at Otago Medical School was one commonly found in specialized chemistry and biochemistry courses. There was no single textbook which was suited for the course, so lecturers produced handout notes to ensure that students received essential information. The handouts were so good that some students could not see why they needed to attend lectures at all. Rather than considering this a problem, the course lecturers set out to enhance the effectiveness of the lecture notes to help students learn *outside* the lecture hall. The new course which evolved from these efforts is discussed in the article *Teaching Methods Down Under* (in *Biochemical Education,* No. 1, 1980).

The subject matter of the course was divided into a series of units—each unit containing material which would have been in one lecture. A lecturer prepared a text for each unit (2 - 8 pages long, frequently including tables and diagrams), which a second lecturer helped prepare or revise. The units were collected into a book, which was printed by simple photo-offset reproduction, and sold to students at slightly below cost. At the start of each unit, a list of required references was provided, as well as reading material suggested for students who wanted to learn more about the particular topic. Several copies of the required references (good, concise, and preferably illustrated material) were put on reserve in the library. Some of these were tape-slide programmes prepared by course lecturers. In order that students stop the programme and think about the points raised, each programme includes a worksheet with questions. Written transcripts of the programmes are available to students who prefer to read rather than listen to a tape.

The entire course content is available to students in written (or recorded) form, and it is made clear to students that no new examinable material would be presented in class sessions. Attendance at class sessions is entirely voluntary, and in fact, half to two-thirds of the students do not attend. The sessions are used to clarify difficult points, answer questions, show slides and solve problems. At the end of the sessions, students are given a quiz to reinforce a few major points of the unit material and help them evaluate their own understanding. No records are kept of student performance on these quizzes, but the lecturer can judge the response to each question by asking the students to hold up colour-coded cards corresponding to the answer they selected to the multiple-choice question. Afterwards, the questions and correct answers are discussed.

Dr. Schwartz admits that the new course format does not overcome the tendency of students to cram the material hurriedly before final examinations. Overall however, his department feels that there has been a great deal of improvement in student performance. After 2½ years of operating the course, the department has no intention of reverting to traditional lectures. In his article, Dr. Schwatz offers to send additional information to anyone who wishes to write (Dept. of Clinical Biochemistry, University of Otago Medical School, Dunedin, New Zealand), and will provide a copy of the course book for US$5.

And, a new method allows students to perceive atomic orbitals

The recent trend to orient chemical education towards applied chemistry problems highlights a need for theoretical chemists to "sell" the importance of this subject. And surely, the people who need to be sold most are students, many of whom are overwhelmed by the mathematical treatment of electron orbitals, derived from the fearsome-looking Shrödinger equation.

The first close-up view of atomic orbitals? It is, for some students. Actually, these 'orbitals' are simulated by vibration modes of a steel plate made visible by holographic photography (a technique used by engineers for studying vibrating objects). Vibrations are governed by mathematical equations similar to those applying to electron waves, except that the vibrations are constrained to two dimensions. Here, vibration modes corresponding to atomic 2*p*, 3*d* and 4*d* orbitals are visualized. Each dark line discloses where the plate has moved the same distance (relative to the next dark line), and represents a contour of constant electron density.

Perhaps if they could see some tangible, visible representation of the Shrödinger equation results, this would make the subject a more salable product in the university curriculum.

Indeed, greater student interest is reported by A. G. Massey and S. K. P. Timeaus with a novel teaching method used at Loughborough University in the U.K. By including mechanical vibrations in a steel plate, they create conditions for wave motion that are analogous to that on which the Shrödinger equation is based, and simulate the same boundary conditions pertaining to atomic orbitals. Back-and-forth movement of standing waves in the plate correspond to the electron density of electron orbitals. This is visualized by holographic techniques, providing contour maps of 'electron density' (displacement of the plate's surface). The plate is viewed with monochromatic light—and where the plate has moved a distance equal to one wavelength of the illuminating light, destructive interference of the reflected light causes this area of the plate to appear dark. Alternately, the plate can be viewed by electronic speckle interferometry, which allows the vibration pattern to be stored on videotape or displayed on a television screen so that a whole class can watch as each 'orbital' is tuned. The 'orbitals' occur at discrete frequencies corresponding to allowed electron energy levels in an atom.

"The student is taught three main points", note Massey and Timaeus. "Firstly, he can see the 'actual shape' of the 'orbitals' and thus appreciate how an electron standing wave would give similar orbital contours. Secondly, the presence of the the two diameter nodes in the *d* 'orbitals' is clearly demonstrated, the plate vibrating in opposite directions on either side of a node. This allows analogy with the concept of orbital symmetry where upward and downward displacements of the plate's surface are denoted by the symmetry signs + and - respectively. Thirdly, he can see the direct relation between the number of circular nodes present and principal quantum number of *s, p,* or *d* orbitals."

Greater utilization of fuel resources highlights need for combustion research

Increasing emphasis on fuel conservation and utilization of all available fuel resources has incited much activity in the design of new combustors. These devices offer the capability to burn low-grade, highly viscous or mixed fuels—providing unprecedented efficiency and versatility. One new combustor (developed by the Katayose Industrial Company Ltd in Japan) can be fired with asphalt and tar pitch. These hydrocarbon byproducts had previously been considered unsuitable for use as fuel, in spite of their high heat of combustion, because they are tarry solids at room temperature. Another burner was developed in Canada to reduce consumption of heavy fuel oil in industrial boilers. It produces a flame of higher temperature, allowing more of the heat output to be utilized. A major research effort is presently underway to develop fluidized-bed combustors which can burn high-sulfur coal, yet emit little pollution (see *IUPAC Information Bulletin,* 1979, No. 2).

These engineering improvements have proceeded despite the lack of basic chemical understanding of the combustion process. It seems incredible that so little emphasis has been devoted to understanding combustion, especially since chemists routinely exploit the chemical characteristics of hydrocarbon combustion in flame ionization detectors. These small devices are probably the most versatile and widely used gas chromatography detectors, but have been largely overlooked by combustion researchers. About 40 000 Flame Ionization Detectors (FID's) are now in use throughout the world.

Combustion of organic compounds in a hydrogen flame produces relatively few ions: about one ion is formed for each hundred million neutral molecular fragments. But, ions can be so easily extracted from a flame by an electric field, and the resulting electric current measured so accurately, that flame ionization provides an extremely sensitive means of detecting organic compounds. Identification of the ions with a mass spectrometer provides even more information, from which may be gleaned valuable clues about free radical reactions occurring during combustion.

Tiny traces (10^{-5} micrograms) of organic compounds in a hydrogen flame produce a detectable number of ions. The response of a Flame Ionization Detector is proportional to concentration over an enormous range. Equally important, *no* ions are produced when organic compounds are *not* present in the fuel. Flame ionization is thus ideally suited for the detection of organic compounds present in the helium or nitrogen carrier gas leaving a chromatography column.

Ionization occurs with virtually all organic compounds in a hydrogen flame. The degree of ionization depends in a predictable way upon the number of carbon atoms in the sample. For example, a Flame Ionization Detector provides the *same response per molecule* for the six-carbon compounds n-hexane, cyclohexane and benzene, despite their very different chemical and thermochemical properties. There are several important exceptions: *no* ions result during the combustion of CO, CO_2 or H_2CO, HCOOH and CS_2. Until recently, there was no clear, simple explanation. No one could explain why other molecules gave the same response for each CH, CH_2 or CH_3 group in the molecule and a somewhat lower response for other functional groups.

As frequently happens when a comparatively simple device arrives to fill a long-felt need, chemists in many specialized areas have used the flame ionization detector, optimized its performance and referred to it in thousands of publications, but few devoted their attention to understanding combustion processes on which it operates. Very rapid chain reactions occurring in flames can now be studied with newly-developed laser techniques, and reportedly, the onset of combustion can be monitored by including specific photochemical reactions with a laser radiation pulse. However, most of our present knowledge of flame ionization has been gleaned by mass spectroscopists. In a most interesting article "Ions in the Flame Ionization Detector", one research group explains fundamental insight into combustion processes which has been derived from ionization experiments. Their article, published in the annual report of the Chemical Physics Division of the Commonwealth Scientific & Industrial Research Organization (CSIRO) of Australia, summarizes what has been learned since ionization was first observed in flames about 20 years ago.

It is generally believed that ionization in all flames begins with the reaction:

$$CH + O \rightarrow HCO^+ + e,$$

although most evidence is indirect. This is one of the few plausible reactions which liberate enough energy to eject an electron (the free electron ultimately becomes bound in a CO_3^-,

HCO_4^-, NO_2^- or NO_3^- ion in cooler regions of an FID flame). The energy needed to eject an electron is provided by formation of the strong carbonyl double bond in the HCO^+ ion. This is consistent with the observed requirement that a carbon atom must be present for ionization to occur, and that a carbonyl group produces no ions.

The number of HCO^+ ions reaches a maximum at the flame front, where fuel and oxygen meet, but this ion is detected in only small amounts since it is so reactive. Immediately downstream from the flame front, HCO^+ reacts with water molecules.

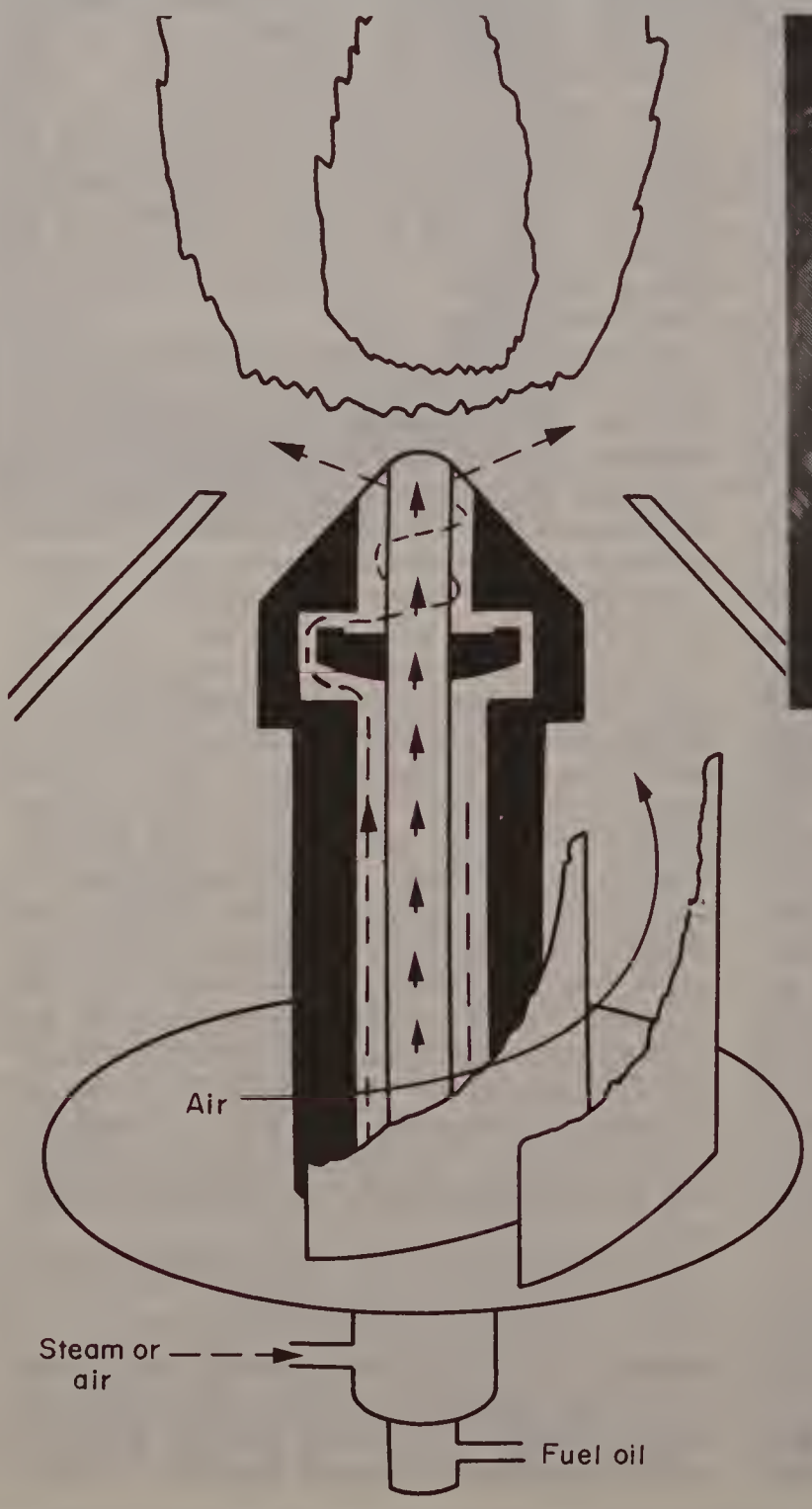
$$HCO^+ + H_2O \rightarrow H_3O^+ + CO$$

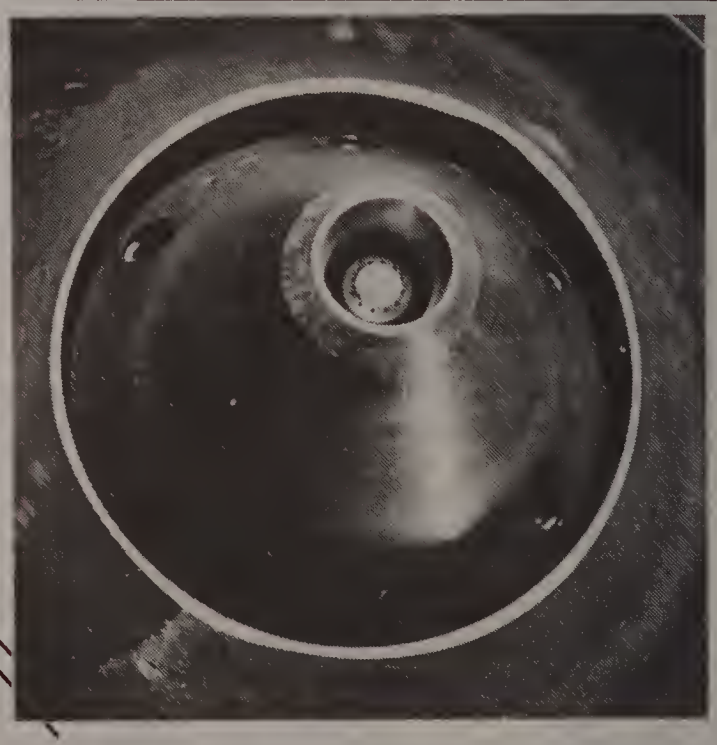
This reaction occurs readily because water molecules have a greater proton affinity than carbon monoxide and are a major constitutent of the burnt gases.

Ion/molecule reactions do not make a major contribution to the overall combustion process. It is free radical reactions which are primarily responsible for the breakdown of reactant gases and formation of combustion products. Nonetheless, because ions are so much easier to detect and identify than free radicals, and because energy-producing ion/molecule reactions are so rapid, a study of ionization processes gives considerable insight into the major chemical processes which occur in flames.

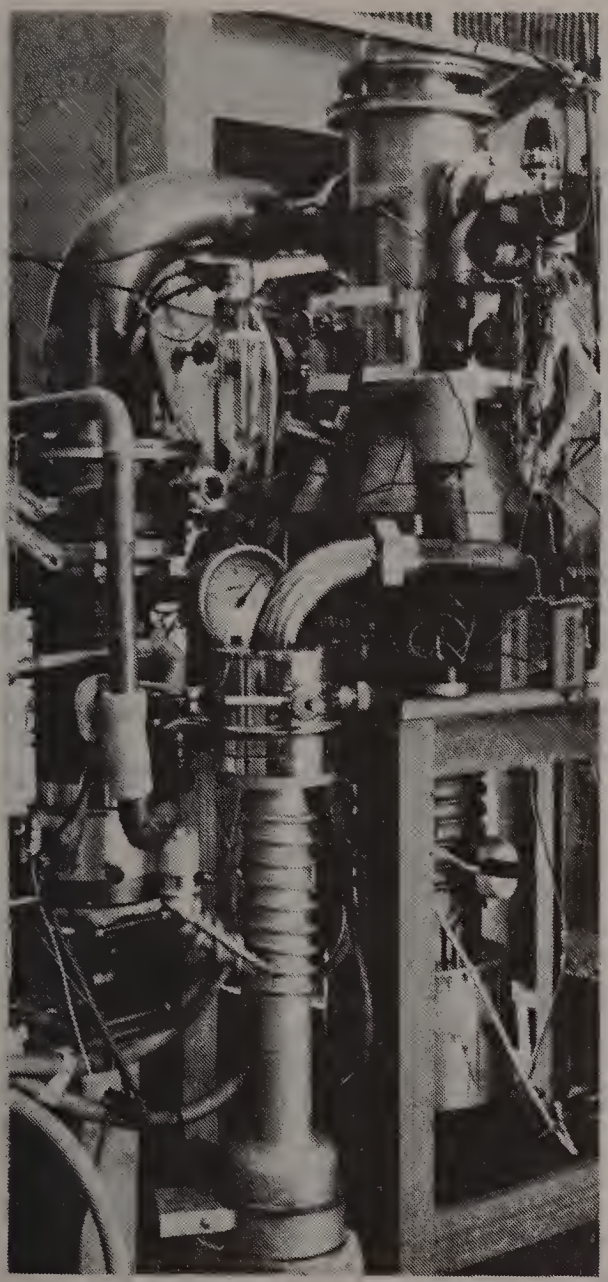
Well before most ionization reactions occur, organic compounds are completely broken down to CH and similar radicals. Recent theoretical calculations confirm that a proposed cracking mechanism could account for the breakdown of hydrocarbons. Firstly, a hydrogen atom abstracts hydrogen from the parent compound to form a free radical. When this radical encounters a second hydrogen atom, it splits into two smaller radicals. This process continues until the parent compound has been broken into single-carbon entities (such as CH and CH_2). The formation of these radicals is indicated by the presence of CH_2^+ and CH_3^+ ions near the flame front.

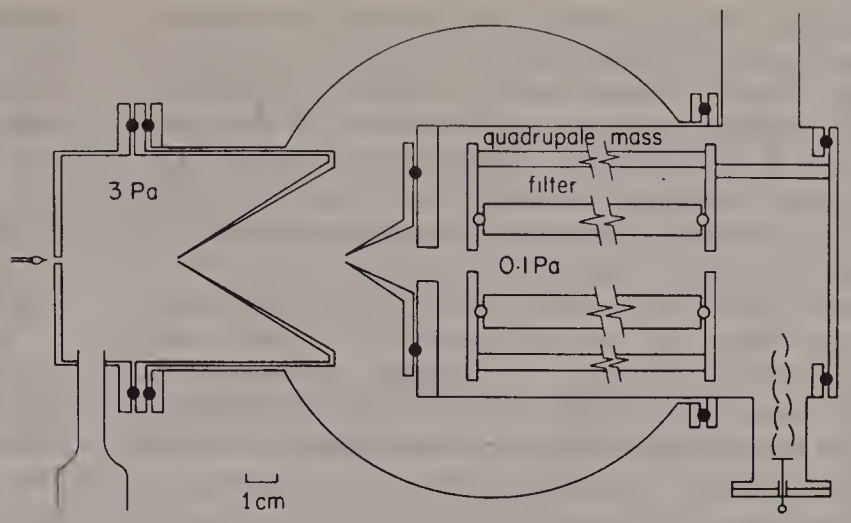
Sampling of the flame with a mass spectrometer indicates that some molecules form near the flame front, although few will survive subsequent reactions in the flame. The production of acetylene, formaldehyde and methanol





More efficient utilization of fuel is achieved by a new combustor developed by Gulf Oil Canada Ltd and Ontario Research Foundation (Canada). The 'vortometric' burner is capable of burning heavy fuel oil with a twenty-fold range of heat output. The burner atomizes a viscous oil spray into fine droplets with high-frequency sound generated at the burner head by a low-pressure steam vortex. The oil mist vaporizes before it reaches the flame front beyond the burner tip. Because the burner achieves complete combustion with a stoichiometric quantity of air (as compared to the 25% excess air required by conventional oil burners), it produces hotter exhaust gases which can be utilized more efficiently. Initial applications of the new burner include a copper smelter in Canada; distilleries in Britain, France, Germany and Brazil; and a fertilizer plant in Pakistan. (*Photograph courtesy of Gulf Oil Canada Ltd.*)





Ions formed in the hydrogen flame of an FID detector are studied with this apparatus at the CSIRO Division of Chemical Physics Laboratory (Australia). Different parts of the flame are sampled as the distance is varied from the flame tip to the entrance orifice. Gases sampled from the flame are reduced in pressure by several stages of differential pumping before entering the quadrupole mass spectrometer, which monitors the number of ions of the selected mass/charge ratio. The most visible components of the apparatus are diffusion pumps, cold traps and other equipment to maintain a high vacuum in the mass spectrometer. Not shown in this photograph (provided courtesy of Dr. A. J. C. Nicholson, CSIRO) are gas metering devices, electronic equipment and rotary pumps.

are indicated by the presence of protonated ions of these compounds. These same protonated ions form regardless of the parent compound, exactly as would be expected from combination reactions or oxidation of CH, CH_2 and CH_3 radicals. Surprisingly, the major ion which is present within a very narrow zone near the flame front is $C_3H_3^+$. The origin of this ion has been the subject of much dispute, and has never adequately been explained.

Downstream from the flame front, the only detectable ion species are the oxonium ion (H_3O^+) and its hydride clusters ($H_3O^+(H_2O)_n$). It is these ions which carry the charge in a flame ionization detector.

Standard test methods aid research, assist international trade

As more and more cooperative research programs are undertaken by laboratories in different countries, it is becoming increasingly important to establish uniform methods of chemical analysis, capable of providing consistent results when performed by different individuals in different countries.

When trace concentrations of substances are measured, it is often difficult to ensure that any laboratory result is a reliable absolute value. Very different results can be obtained by several laboratories testing the same samples with dissimilar procedures. The failure to recognize the importance of standardized test methods had been a common cause of incorrect interpretation of results, wrong conclusions, and even serious disputes between buyers and sellers of chemical commodities.

One clear example is provided by the monitoring of nickel concentrations in human body fluids and tissues, which has been undertaken on a widening scale during the last decade. In order to determine if results obtained by different laboratories were comparable, the IUPAC Subcommittee on Environmental and Occupational Toxicology of Nickel conducted two surveys in which urine specimens were distributed to laboratories in seven countries for analysis of nickel levels. Both surveys disclosed wide discrepancies in nickel concentrations reported by participating laboratories. Although all the laboratories had determined

nickel concentrations with atomic absorption spectrometry, the analyses differed in sensitivity, nickel recovery and precisions, depending upon the preliminary pretreatment of the sample. A preliminary concentration step is required to oxidize organic constituents and concentrate nickel present in the sample (usually, at part-per-billion levels for human tissue). It is here that troublesome contamination problems are likely to be encountered. Pipets and specimen containers are readily contaminated by the relatively high nickel content of sweat on the hand of laboratory workers. Micropipetting instruments frequently have plastic cone-tips that are contaminated with metals, as are commercially-available evacuated tubes for collection of blood samples. To avoid contamination, all equipment must be scrupulously cleaned by soaking in ultrapure HNO_3 and rinsed repeatedly in demineralized water.

Until recently, there has been no critical review of analysis methods for measuring nickel concentrations in biological materials. This need has now been met by a report *Analytical Biochemistry of Nickel* prepared by the IUPAC Subcommittee on Environmental and Occupational Toxicology of Nickel (published in *Pure & Applied Chemistry,* 1980, No. 2, p. 529).

IUPAC groups have published other reports recommending standard analysis methods. Reports published last year have suggested or discussed standard methods for measuring mercury and copper concentrations in foodstuffs; residues of pyrethrin insecticides; nutritional value and impurities in Single Cell Protein; trace metals in lead alloys; and determination of steroids, aldehydes and ketones.

The importance of standard test methods and consistent reporting of results was recognized very early by companies involved in the production and processing of vegetable oils. As early as 1924, industry representatives acknowledged that test methods must be standardized if disputes were to be avoided. It had then already become apparent that slight modifications to test procedures could—under otherwise identical conditions—significantly alter the results obtained. Furthermore, criteria of quality (such as unsaturation, oxidation, free fatty acids, and pesticide residues) needed to be clearly defined in sales contracts. In one case, failure to standardize the reporting of test results caused a serious dispute over the sale of illipé seeds by a Dutch firm to a French firm. Several types of fatty acids may be present in vegetable oils, and while the amount of free fatty acid is generally reported in terms of either oleic acid or of lauric acid, this had not been agreed in advance. A group of arbitrators could not agree amongst themselves, and finally, the chief arbitrator decreed that the average molecular weight of illipé fatty acids would be used to evaluate the acidity of the product in terms of lauric acid.

Publication of uniform testing procedures is the main function of the IUPAC Commission on Oils, Fats & Derivatives. The group periodically replaces outdated tests, and recommends new test procedures as their need becomes apparent. In December 1979, the Commission issued procedures for four new tests for vegetable oils, margarine and other food products:

Determination of Oil Content (Low Resolution NMR method)
Determination of 'Oxidized Acids' (by Thin Layer Chromatography)
Determination of Organochlorine Pesticides
Determination of Total Fat in Margarine

These four tests (published in *Pure & Applied Chemistry,* 1979, No. 12, pages 2505 - 2524), comprise a supplement to the recently updated (6th Edition) hardcover volume "Standard Methods for the Analysis of Oils, Fats & Derivatives" (1979, Pergamon Press, 170 pages, US$18).

IUPAC is by no means the only organization recommending standard methods of chemical analysis and presentation of results. One of the foremost organizations in this area is the International Standards Organization (ISO). Within the last decade, ISO has taken an increasingly active role in recommending standard methods for evaluating major products of international trade. Of the 4000 ISO standards that have been published, 90% have been issued or revised in the last ten years. Significantly, many have been composed not merely to complement existing national standards, but to replace them. Twenty-five ISO working groups formulate standard methods for testing basic chemical products. To ensure uniform terminology, IUPAC Commission members have participated in meetings of these working groups. Information about ISO test methods can be obtained from the organization's Secretariat at Case postale 56, CH-1211 Geneve 20, Switzerland.

Pharmaceuticals are one type of chemical product for which testing, although generally stringent, may vary widely from country to country. Some nations publish their own standard test methods for pharmaceuticals (for example, the *United States Pharmacopoeia* and *National Formulary* in the USA, *British Pharmacopoeia* in the UK), but an *International Pharmacopoeia* is published by the World Health Organization. Volume One, *General Methods of Analysis,* has just been published and provides a description of 42 general methods of analysis for pharmaceuticals. Technical and economic limitations faced by quality control organizations in developing countries were fully considered in recommending analysis procedures. Four subsequent volumes will contain quality specifications for individual drugs, particularly those that are widely used in health care. The *International Pharmacopoeia* is intended as a reference for national authorities, with the aim of improving quality standards for all drugs—those that are imported as well as manufactured locally. The 223 page First Volume is available from WHO offices (price: 24 Swiss francs).

The molecular basis of drug action

In the past, new drugs originated from chance discoveries, when alert chemists recognized the biological activity of substances they had made (often by accident). Now, the development of new pharmaceuticals proceeds . . . usually . . . on an entirely different course. It is often possible to *predict* a chemical structure which will provide the desired biological activity, and then go about synthesizing the new compound. How do drugs work, and what is the underlying strategy behind the design of new drugs? In other words, what is the molecular basis of drug action?

by Prof. Adrien Albert
Australian National University

From time to time one encounters a pair of closely related substances, of which the first has strong biological activity whereas the other has none. How can such molecules, which may differ by only a single methyl group, perform so differently on a living organism?

Under the strong pressure of natural selection, many small and highly selective molecules have evolved to regulate the work of the living cell. They govern its nutrition, growth, and reproduction. Examples of these *natural agonists* are the vitamins and coenzymes, the hormones and neurotransmitters, and the inorganic cations (some light, some heavy). Also the purine and pyrimidine bases of DNA which, through their sequences, encode the cell's heredity and consequently instruct its behaviour from moment to moment. Each natural agonist interacts with a complementary biopolymer, such as a protein or nucleic acid, to generate responses adequate for the cell's metabolism and survival.

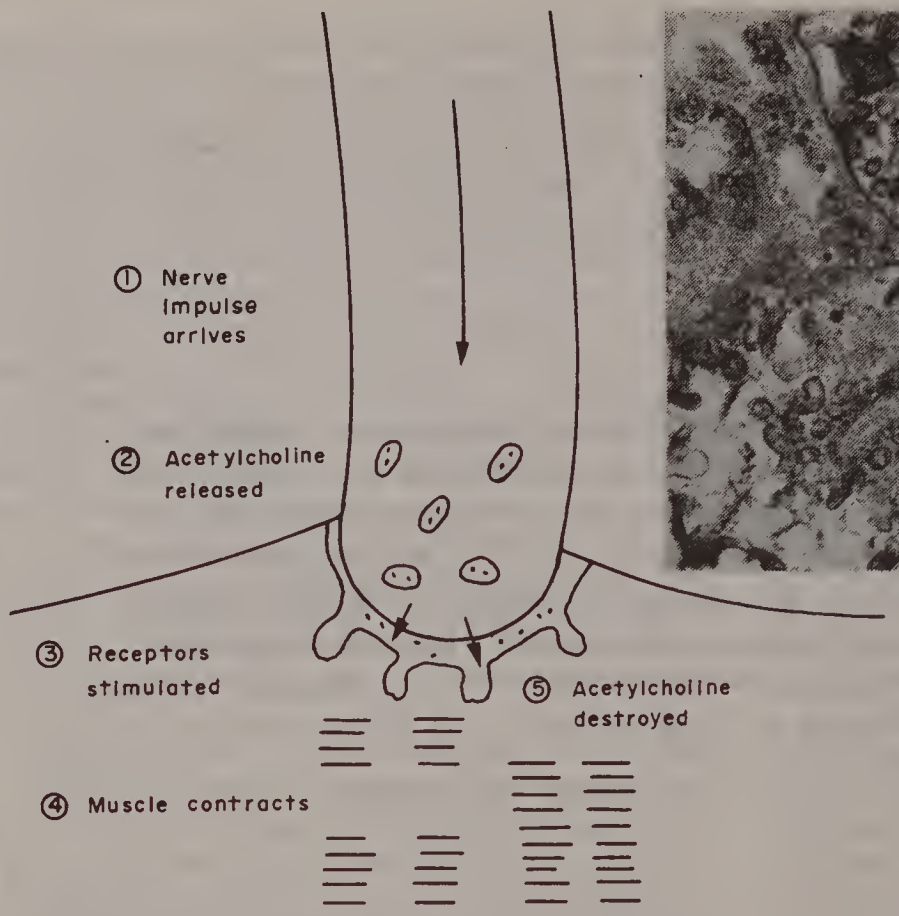
Man's drugs are of three kinds: replacements, redesigned agonists, and antagonists. Those in the first class, such as vitamins, hormones, and minerals, are used for simple replacement, as in the replenishment of phosphorus and calcium during pregnancy.

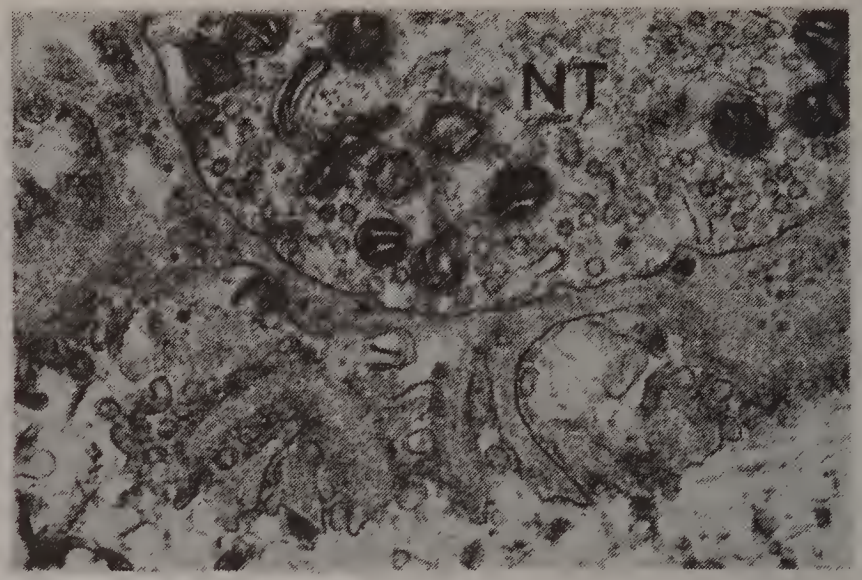
The second kind is the modification of a natural agonist in order to prolong its action, retard its elimnation or degradation, or cause it to act locally rather than generally. The therapeutic steroids provide many examples of these modified agonists, e.g. both male and female sex hormones are esterified to make depots which release the hormone only slowly from the site of injection. Other female hormones are rendered less patient-biodegradable by inserting a methyl or even a fluorine substituent.

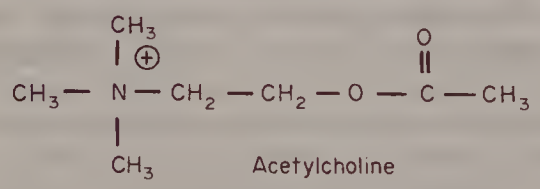
This recipe, for finding agonistic drugs by redesigning natural agonists, is often applied to the neurotransmitters. These are small molecules that carry the nervous impulse across the gap between one nerve and the next, or between the end of that nerve and a gland or muscle. The most widely deployed transmitter in the human body is acetylcholine. Immediately after each molecule of this substance delivers its message, it is destroyed by the enzyme acetylcholinesterase. However, for medicinal purposes (as in postoperative retention of urine, or in the eye disease called glaucoma) it is desirable to prolong the action of this agonist and even, in some cases, to limit its sphere of action as well. To these ends, the drugs carbachol and methacholine were designed. Carbachol differs from acetylcholine only in the replacement of a methyl group by an amino group in the acylating portion of the molecule. In short, the molecule has been changed from an aliphatic ester to a urethane. In this new form, the agonist is no longer affected by acetylcholinesterase. Hence its action lasts very much longer than that of the natural transmitter while remaining just as widespread. Not so with methacoline, which differs from acetylcholine only in having a methyl group inserted into the choline section of the molecule. Like carbachol, methacholine is not attacked by the enzyme, but its powerful acetylcholine-like action is limited in certain sites, e.g. to involuntary muscle.

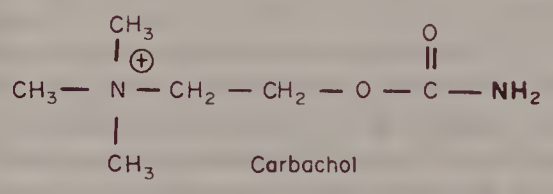
Although Man's use of replacement therapy and redesigned agonists has provided him with some useful therapeutic aids, the majority of his drugs are *antagonists.* Their mode of action is indicated by the Greek root "agon": a contest. Antagonists are designed either to attack invading organisms (such a use is called chemotherapy), to suppress pain, or else to rebalance a biochemical disturbance (this use is called *pharmacodynamics*). Chemotherapy and pharmacodynamics together constitute that branch of science known as *pharmacology.*

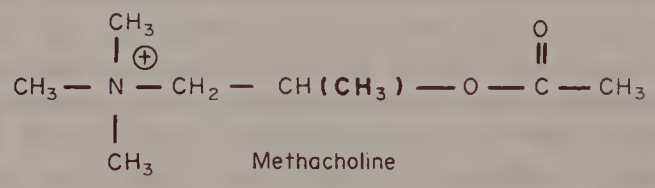
Provided that antagonists are sufficiently selective, they can enlist the valuable powers of toxicity into the service of man. Here we are speaking of *selective toxicity,* namely the ability to injure one kind of living matter without harming any other kind, even when the two kinds are in intimate contact. Depending on the problem in hand, some kinds of molecule are chosen for the ability to effect permanent injury






Acetylcholine


Carbachol


Methacholine

One of the most important natural compounds—from the view of the drug designer—is acetylcholine. It plays a crucial role in transmitting impulses from one nerve to another, or from a nerve to a muscle. Upon arrival of an impulse at a nerve terminal (NT), acetylcholine is released. It diffuses across the narrow gap separating the nerve fibre from a muscle, or another nerve. After crossing the gap, acetylcholine activates a receptor, causing the muscle to contract. It is then rapidly destroyed by the enzyme acetylcholinesterase.

The junction of a nerve terminal with rabbit muscle is shown in this electron micrograph at 31 500 times magnification (photo reproduced with permission from *Neuroscience*).

There are many applications in medicine where it is desirable to modify the transmission of nerveimpulses. Some drugs, such as carbachol and methacholine, act by mimicking acetylcholine. With their very similar chemical structure, they stimulate the receptor—but are not subsequently destroyed by acetylcholinesterase.

(useful in chemotherapy) whereas others are valued because they exert a gently graded and finally reversible injury (useful in pharmacodynamics).

General anaesthetics provide an early (1864) and clear example of the selective use of toxicity. Obviously the value of an anaesthetic is proportional to its toxicity—provided that this toxicity is confined to the central nervous system and is completely reversible with time. Toxicity to other tissues must be negligibly low, and even the toxicity to the target tissue must disappear rapidly when administration is halted. So too with local anaesthetics, muscle relaxants, and antagonists to histamine and the neurotransmitters.

Selective drugs are usually synthetic and of low molecular weight (less than 500). Some, however, are of natural origin but are used completely outside their natural biological function (examples: alkaloids and antibiotics). Vaccines and immunochemicals are placed in an entirely separate category by their enormous molecular weight and radically different mode of action.

Fundamental to any discussion of the molecular basis of drug action is the concept of the *drug receptor.* This idea began with J.N. Langley in Cambridge (1878) and was adapted and made better known through the work of Paul Ehrlich (1854 - 1915). Ehrlich visualized receptors as small, chemically-defined areas on some of the cell's larger molecules. He obtained evidence that the receptor for the arsenical drugs used in treating syphilis and trypanosomiasis (tropical sleeping sickness) was the mercapto-group on some undefined, but vital, cell constituent in the parasite. At first, the receptor concept met with scepticism because of failure to isolate any receptor material. The idea took firmer hold in

the 1930's through the accurate equilibration studies of A. J. Clark, much of it done in London. He showed that quantitative data, obtained on whole organs or (better) on single cells, pointed to formation of a bond (not necessarily a covalent bond) between a drug and another chemical group specific for this drug. Further, he found that the rate of combination between drug molecules and these receptors was proportional to their concentrations.

The high biological specificity of most drugs reminded many scientific workers of the high specificity of coenzymes for their particular enzymes. This prompted the thought that some receptors could be the active sites on enzymes. It was easily shown that a receptor did not bind a drug very tightly, as a rule, and never changed it chemically. Thus drugs were not comparable to enzyme substrates but to coenzymes and enzyme inhibitors. Support for this thought was obtained in 1929 when the alkaloid pilocarpine (still used in glaucoma) was found to act by inhibiting the enzyme acetylcholinesterase. This inhibition enables the patient to have unusually prolonged 'medication with his own acetylcholine. Although this effect of pilocarpine is obtained by antagonism, the end result is agonistic and hence this drug is called a *pseudoagonist.*

Today we could list a great many drugs which have been shown to have, for their receptor, the active site on a particular enzyme. Some examples of much-prescribed chemotherapeutic agents are the antibacterial sulphonamides (target enzyme: dihydrofolate synthetase), penicillin (acts on the bacterial cell-wall enzyme transpeptidase), rifamycin (target enzyme: RNA polymerase). Also, the organophosphate pesticides achieve their insecticidal activity in this way. The antibacterial drug trimethoprim and the antimalarial pyrimethamine act by inhibiting dihydrofolate reductase in the attacking micro-organisms without harm to the analogous enzyme in the human hosts.

Many pharmacodynamic agents, too, act by enzyme-inhibition. For example, allopurinol was carefully designed to fit, and block, receptors on two sequential enzymes (hypoxanthine oxidase and xanthine oxidase). This drug is providing superlative treatment for gout, by suppressing formation of uric acid from the body's store of hypoxanthine. Another example is aspirin which owes its anti-arthritic action to blocking cyclo-oxygenase, a prostaglandin-synthesizing enzyme. Digitalis exerts its beneficial action, namely slowing and strengthening the heartbeat, by inhibiting the particular kind of adenosinetriphosphatase located in the heart.

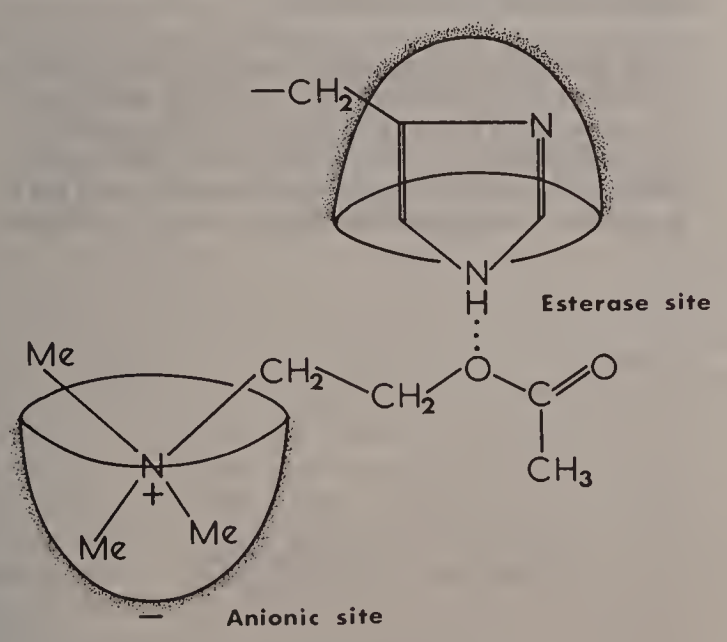
Many of these enzymes have been isolated in a pure state, which has permitted accurate monitoring of drug action. But not all receptors are on *enzymic* proteins, and as we'll see, some receptors are found on non-protein molecules.

About 1950, it began to be realized that the receptors for neurotransmitters must be on *permeases,* non-enzyme proteins that regulate the ingress and egress of inorganic ions through the cell's outer membrane. Each molecule of acetylcholine, when combined with its specific permease at a synapse (a nerve - nerve or nerve - muscle junction), propels about 50 000 inorganic cations across the membrane. The biopolymer (a glyco-protein) that contained this receptor was isolated in milligram quantities from the electric tissues of shock-dealing fish (by Changeaux in Paris, about 1975). It is stable at 0°C for only a few days, but has furnished kinetic results that closely resemble those obtained on whole organs. These tests measured quantitatively the uptake and exchange of radioactively-labelled agonists and antagonists of this receptor. Since 1975, receptor-bearing proteins have been isolated for many other types of neurotransmitters, although in still more minute amounts.

Other common receptors for drugs are the nucleic acids, particularly DNA (Deoxyribonucleic Acid). The aminoacridine antibacterials, widely used to prevent infection of wounds during the Second World War, act in this way (as was first indicated by the present author in 1941). Employing a variety of physical techniques, it was later shown that these acridines (for example, proflavine) become stacked between the purine - pyrimidine base pairs of bacterial DNA, interfering with its function. This stacking phenomena is called intercalation, and it requires only that the drug molecule should have a flat area of 38 A^2, and be ionized as a positive ion at the cellular pH (usually 7).

It is now know that many drugs with these specifications act by intercalation, among the anti-trypanosomal phenanthridines, the antimalarial acridines (e.g. mepacrine, 'Atebrin') and 4-amino-quinolines (e.g. chloroquine), and the anticancer drugs adriamycin and actinomycin. Drugs that have DNA for a receptor, without undergoing intercalation, include the furanocoumarins (repigmenters of skin that has lost its natural colour) and all the steroid hormones. But in the latter case we see a sequence of receptors at work, for the first receptor is a transport protein specific for each hormone, and the DNA is the final receptor.

Small molecules can also be receptors. The



Over the years, considerable attention has focussed on the binding of acetylcholine to the enzyme which destroys it, acetylcholinesterase. In the 1950's, it was believed that electrostatic interactions bound the molecule to the active site of the enzyme, as depicted here. It is now known that the interaction is more complicated than this, and includes conformational changes in the enzyme.

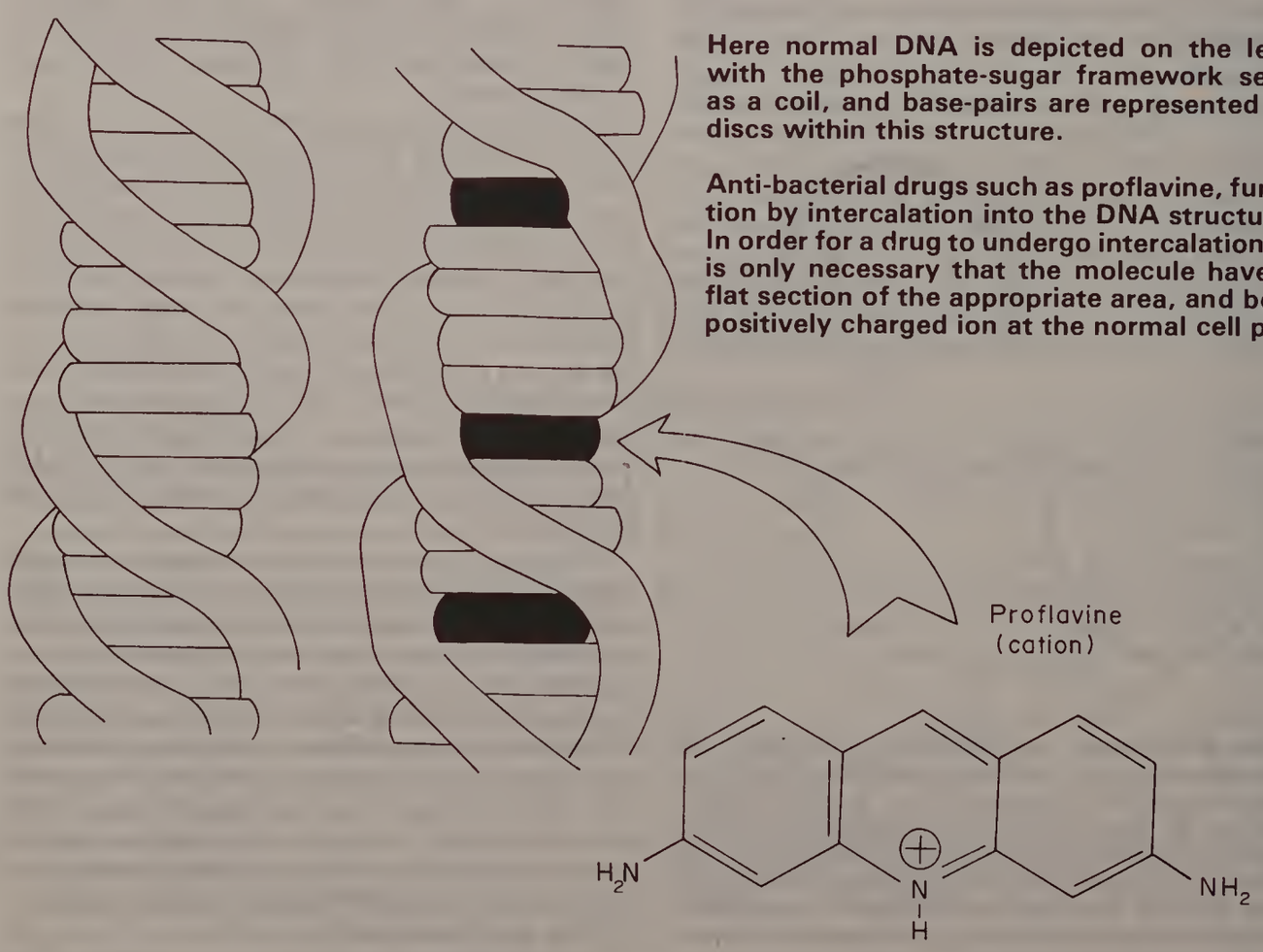
8-hydroxyquinoline antibacterials and fungicides act by chelating a variable-valence metal, such as iron or copper. This combination then propagates a destructive chain reaction. The actual target was found to be the coenzyme (thioctic acid) of pyruvic decarboxylase.

Around 1950, many researchers were preoccupied with thoughts of enzymes as drug-receptors. They constructed imaginary diagrams of active sites. These were devised from a knowledge of the shape and charge of substrate groups common for a particular enzyme, or from molecular structures essential for antagonists of this enzyme reaction. It was as if one was trying to learn the nature of an enemy airfield by landing unmanned planes on it. In 1950, Wilson and Bergmann observed the change in efficacy of acetylcholinesterase with changing pH. They postulated that the enzyme anchored the quaternary amino-group of acetylcholine with an acid group (from a tyrosine residue in the protein chain), and attracted the negatively-charged end of the molecule with a basic group (from a histidine residue). Bound to the enzyme in this way, acetylcholine is hydrolyzed to acetic acid and choline. Or so it was thought.

But it was soon found that 3,3-dimethylbutyl acetate, which has no amino group, was hydrolyzed by acetylcholinesterase as rapidly as acetylcholine. This indicated that van der Waals forces of the methyl groups in acetylcholine could be more important than the positive charge for binding this end of the molecule to the enzyme. Furthermore, it was found that some compounds (such as organic phosphates) inhibited the enzyme function by forming a covalent bond to the oxygen atom of serine (one of the amino acid residues comprising the enzyme). It is now known that the ester group of acetylcholine first makes contact with a histidine residue, which presses it against the serine residue. The destruction of acetylcholine by its enzyme is clearly more complex than had previously been thought.

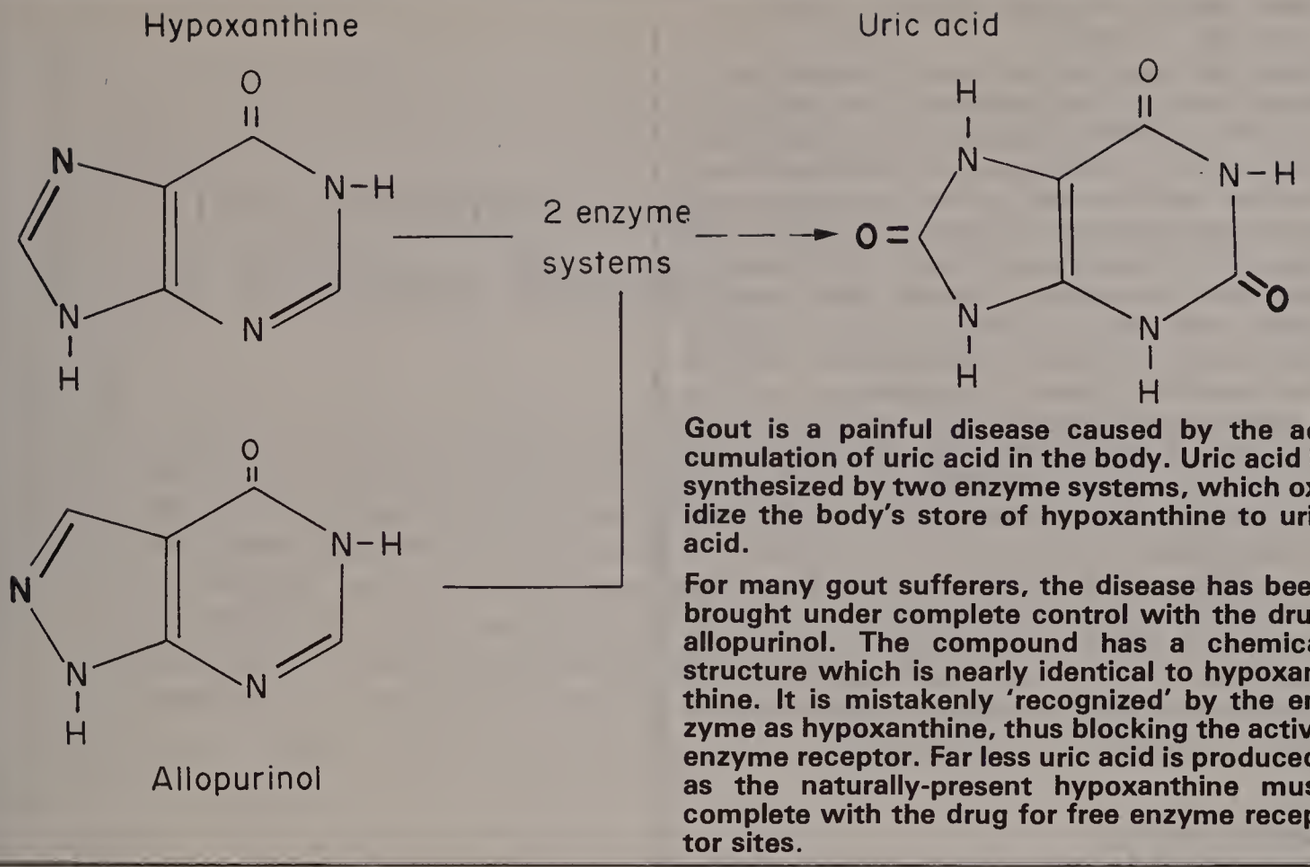
To understand the working of an enzyme, it is best to determine the sequence of its amino acids, and then proceed by X-ray crystallography to work out structures for the enzyme—first alone, then in the presence of substrates, and finally with inhibitors. In this way, enzyme action has been found to proceed by a series of conformational steps. Through this type of painstaking work, Lipscomb revealed (in 1970) how the enzyme carboxypeptidase A undergoes a series of intricate conformational changes. Each brings various segments of the enzyme protein chain into contact with the substrate, causing the substrate molecule to become strained, polarized, and ultimately hydrolyzed. Few drug - receptor interactions are known with such detail as has been gleaned for carboxypeptidase A, but there are many indications that such complex conformational movements are common. A simple means of examining the drug -

One means of attacking bacteria or cancer cells is by interfering with the function of their DNA. To be effective as a drug, a compound must exhibit selective activity towards these cells, and not harm normal body cells.



Here normal DNA is depicted on the left, with the phosphate-sugar framework seen as a coil, and base-pairs are represented as discs within this structure.

Anti-bacterial drugs such as proflavine, function by intercalation into the DNA structure. In order for a drug to undergo intercalation, it is only necessary that the molecule have a flat section of the appropriate area, and be a positively charged ion at the normal cell pH.



Gout is a painful disease caused by the accumulation of uric acid in the body. Uric acid is synthesized by two enzyme systems, which oxidize the body's store of hypoxanthine to uric acid.

For many gout sufferers, the disease has been brought under complete control with the drug allopurinol. The compound has a chemical structure which is nearly identical to hypoxanthine. It is mistakenly 'recognized' by the enzyme as hypoxanthine, thus blocking the active enzyme receptor. Far less uric acid is produced, as the naturally-present hypoxanthine must complete with the drug for free enzyme receptor sites.

receptor complex is provided by its nmr spectrum, which shows line-broadening from any drug atom which makes contact with the receptor.

A clear molecular difference between agonists and antagonists has emerged. The design of antagonists is not so critical as that of agonists because they have only to block the receptor, whereas agonists must make the receptor respond. Both types of drug need a certain common structure in order to become attached to the recognition centre of the receptor. One method often used to create an antagonist is to modify an agonist by increasing its molecular weight, for instance by slightly lengthening a paraffinic chain. This not only ensures a longer dwell time on the recognition site, but also creates enough tilt at the active site to make the contact ineffective.

Early researchers who sought a relationship between the structure and action of drugs were misled into believing a 'one-group one-action' hypothesis. The formulation of this theory followed the discovery, in 1869, that very many quaternary amines are muscle relaxants. However, in the 1920's, it was found that one naturally-occurring quaternary amine, acetylcholine, was a potent *stimulator* of muscle. It soon became clear that certain chemical groups (here, trimethylammonium) could impose two opposite actions. Drugs behaved one way if they resembled the natural messenger sufficiently well to take its place (as carbachol and methacholine, mentioned previously), but had the opposite effect if they differed from the messenger enough to interfere with its stimulation of the receptor.

The sulphonamide antibacterials seemed to reinforce the 'one-group one-action' hypothesis soon after their discovery in 1935, but ultimately dealt it a mortal blow. Drug researchers soon discovered that a sulfonamide group imparted antibacterial properties only when the molecule had the necessary charge distrubiton, size and shape. Yet, if these conditions were met, the presence of the sulphonamide group was no longer essential for biological activity; it could be replaced by a different group of similar polarity. Meanwhile, some benzenesulphonamides were found to be useful diuretics and yet others antidiuretics, but none of these had antibacterial properties.

It is now realized that the fundamental requirements for a particular kind of drug action are dictated by the receptor, and that these requirements are physiochemical in nature. For a drug to be effective, it must satisfy three requirements. The molecule must have such a lipophilic/hydrophilic (fat-soluble/water-soluble) balance as will ensure that the drug is distributed to the tissues in which the relevant receptor is located. The molecule must have an electron distribution complementary to that of the receptor, and it must have a size and shape complementary to the receptor.

In favourable cases, these requirements are learned after isolation of the receptor. More often, they are derived by inference from the biological response of an organism to a series of chemically-related substances. In the latter case, some information can often be obtained by statistical handling of partition coefficients and of Hammett sigma and rho values of functional groups (reflecting their ability to withdraw or donate electron charge to the rest of the molecule).

Even if a substance satisfies the requirements for biological activity, that does not specify whether it is a safe, well-tolerated drug or a destructive poison. To progress beyond their point, the *selectivity* of the drug must be taken into account, and this requires close collaboration between chemists, biochemists and biologists. A drug may exert selective activity if it is accumulated preferentially in the cells that one hopes to influence (or possibly, to destroy). Alternately, it may injure a biochemical system important for these cells, or react exclusively with a cytological feature that exists only in these cells.

Some years ago, a Frenchman discovered that

dilute sulfuric acid could safely be sprayed on a cereal crop to destroy the weeds. Sulfuric acid (of which the actual toxicant is the hydrogen ion) is equally toxic to the cytoplasm of both wheat and weed, but it never penetrates into the cereal's cells. The exterior of cereal grasses is smooth and waxy, whereas that of weeds (typically dicotyledons) is rough and absorbent: the acid runs off the cereal grasses, but is accumulated by the weeds. Moreover, the tender new shoots of cereals arise from the plant's base and are protected by leaf sheaths, whereas the growing point of dicotyledons is exposed and vulnerable. Hence the weeds die and the economic crop flourishes. This provides a simple illustration of why selectivity is so important to drug design, and how the increasing attention to drug selectivity is helping to create a whole new generation of safer drugs.

It is fair to conclude that—for all that has been learnt about the molecular basis of drug action—much will still be gleaned from chance discoveries. Yet, to recognize and benefit from fortuitous observations will require prepared minds and full use of present scientific knowledge.

About the author:
Adrien Albert is Emeritus Professor at the Australian National University, Canberra (Australian Capital Territory). He is a Fellow of the Australian Academy of Science.

Additional Information:
The author suggests the following books to enable interested readers to pursue further various aspects of this subject.

"Cell Physiology" by J. Howland, 2nd edn. (1973), London: Macmillan.
"Selective Toxicity" by A. Albert, 6th edn. (1979), pp. 662, London Chapman & Hall.
"Enzyme Structure and Mechanism" by A. Fersht, pp. 371 (1977), San Francisco: W. H. Freeman.
"Basic Biochemistry for Medical Students" by P. N. Campbell and B. A. Kilby, pp. 472 (1975), London: Academic Press.
"Drug Design" by E. Ariens (Ed.), eight volumes (1971 -1979), New York: Academic Press.

by R. N. O'Brien
University of Victoria

and C. Forgacs and J. Schechter
Ben-Gurion University

Salinity power has been a vast store of unused energy lying dormant on the sidelines of the world flow of energy. Previously, those who taught thermodynamics, when dealing with the enthalpy of solution and colligative properties of electrolytes, would make wry references to the osmotic head that *could* be generated where rivers flow into the sea. They will now, with the advent of novel membrane technology, have to alter their notes.

Perhaps the most obvious method of utilizing the chemical potential difference between a dilute and concentrated solution would be by exploiting the difference of vapor pressures of concentrated and dilute solutions. If a vessel containing a dilute solution is connected to one containing a concentrated solution and the air evacuated, we would find that water would evaporate from the dilute vessel and condense in the concentrated solution. At the same time the dilute solution would cool and the concentrated solution heat up and become more dilute. By returning the heat of condensation to the dilute vessel and continuously replacing the two solutions, a continuous flow of water vapor will take place between the two solutions. A turbine strategically placed between the two vessels will then generate electricity. The process can be made more efficient by arranging the vessels in a multi-stage configuration.

This process is, in essence, the reverse of the vapor compression water desalination process. The compressors used for this latter process could, with minimum design changes, be used for generating electricity. Concentrated brines from salt producing

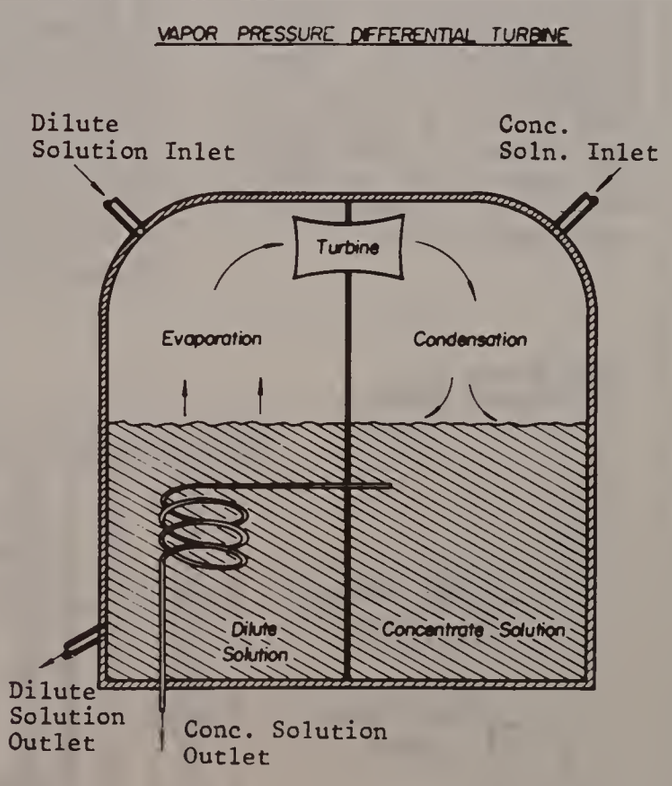
The practical use of Salinity Power

Each day, billions of litres of fresh water flow into the oceans and mix with seawater. The difference in salinity is dissipated uselessly as the solutions mix, much as heat produced by burning fuel is dispersed into the air without an engine to extract mechanical power. Extraction of energy from solutions of different salt concentrations has been recognized as a theoretical possibility for many years. What has changed is the development of new technology which promises to make salinity power into a practical, economic and renewable resource.

operations would probably give best performance with this method. It has been calculated that one ton of end brine coupled with sea water could theoretically produce about 20 kWh of electrical power.

A more practical method might be to utilize the concentration difference between river water and seawater to produce a hydraulic pressure—that is, an osmotic pressure. Ignoring thermodynamic complications, the osmotic pressure that could be produced is the product of the concentration difference (Molarity), absolute temperature, and ideal gas constant. With sodium chloride of 0.5. M concentration (the average salinity of sea water), the osmotic pressure can be between 23 and 24 atm, depending upon the temperature, salt activity and other factors. Taking 10.25 m of water depth as equivalent to one atmosphere of hydrostatic pressure, the theoretical hydraulic head is about 240 m. Once generated, this hydraulic pressure could be used to drive a turbine. Alternatively, a pressure-retarded osmosis system could be used. This would consist of two chambers separated by an osmosis membrane; one filled with saline solution, the other with pure water. The saline solution is under pressure from a piston, with the osmotic pressure driving the piston backward as water permeates through the membrane. The force on the piston is transmitted to a shaft, which is ultimately converted to electricity or used directly as mechanical power. Such a system has much to recommend it, but so far, suitable membranes have not been invented.

The third and—at present—most advanced method for the utilization of salinity power is Reverse Electrodialysis (R.E.D.). Until recently, workable membranes had not yet been made for reverse electrodialysis. To function efficiently, the membranes must have a low electrical (really electrochemical) resistance to *either* positively *or* negatively charged ions. Passage of an ion through the membrane depends upon how easily it can 'hop' from one ion exchange absorption site (RSO_3^- group for cation exchange membranes) to another. It also depends upon the space available (pore size) for ion movement. Good membranes are highly conducting for selected ions, but allow only these ions to pass. It is possible to achieve permselectivities of over 90%. The lack of ideal permselectivity results from leakage



A concentrated salt solution has a lower vapor pressure than a dilute solution (or pure water) at the same temperature. The vapor pressure difference can be exploited to drive a turbine and produce mechanical power.

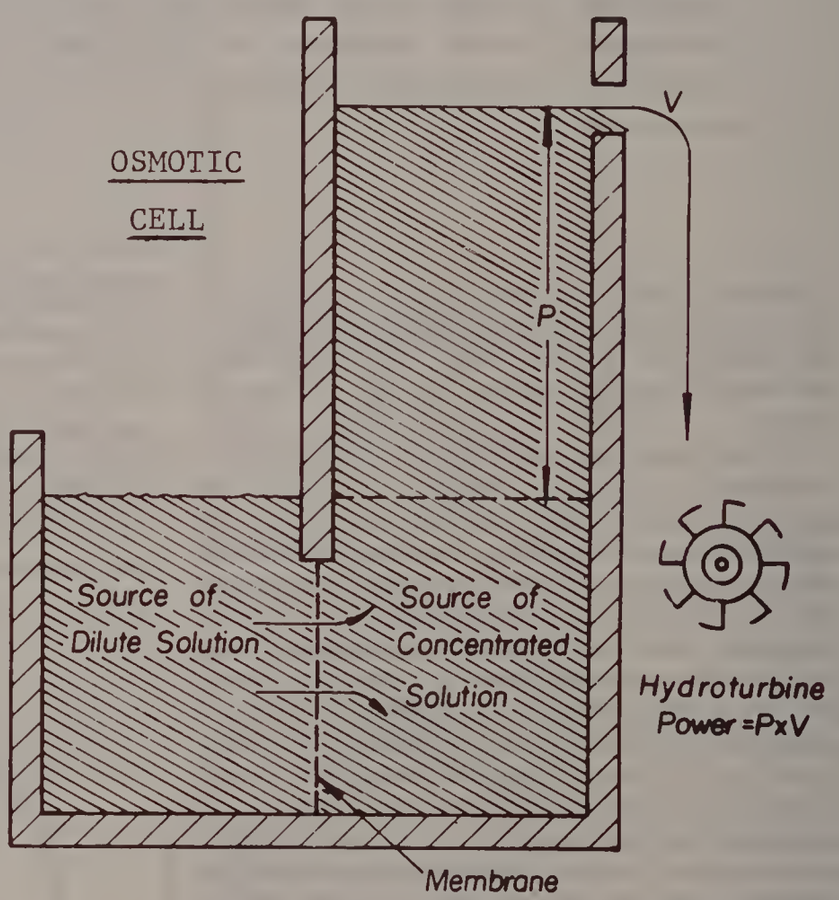
of the co-ion (for example, leakage of the anion in a cation exchange membrane) past a fixed ion of the same charge in the narrow pores. It varies to some extent with the degree of swelling. All ion exchange membranes swell when placed in an electrolyte solution.

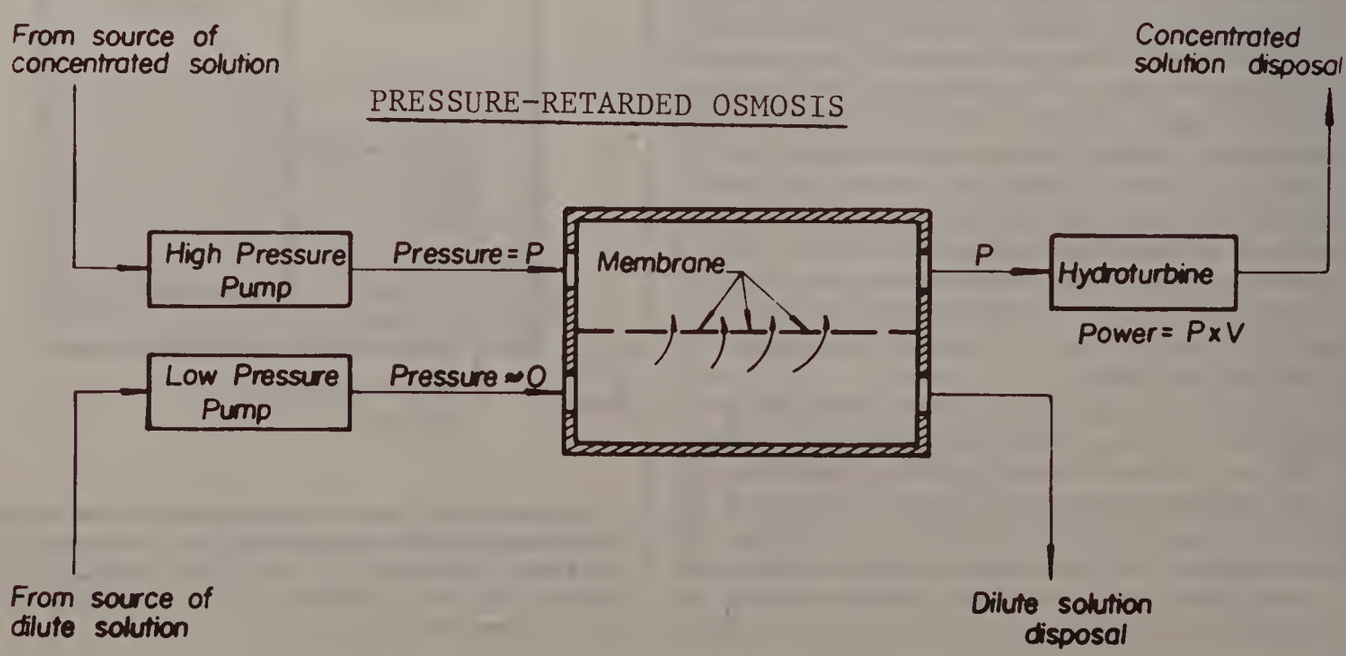
The novel membrane which made R.E.D. practical was developed at Ben Gurion University of the Negev's Research and Development Authority by one of us (C. Forgacs) and co-worker R. Messalem. It is a modification of an earlier membrane developed at the same institute by de Körösy and Shorr. The membrane is made from ordinary polyethylene film which has been sulphochlorinated by photochemical means. This yields a cation exchange membrane upon hydrolysis, or an anion exchange membrane upon aminolysis followed by quaternation. The membranes can be very thin (30 μm) and can have a real resistance of less than 0.1 ohm-cm. The internal resistance of a 'dialytic battery' can therefore be very low if the electrolyte thickness between membrane pairs is small.

Reverse electrodialysis has now attained the position of real potentiality for continuous power generation for ocean-side communities even where modern technology has not yet penetrated. R.E.D. also provides the promise of constant power generation, rain or shine, day or night, so long as a salinity pair (two solutions of different concentration) is available.

Before considering *power generation,* let us first consider the reverse process—electrodialysis, which *consumes power* from an external electricity supply to create a concentration difference. The simplest electrodialysis cell consists of two electrodes and two ion exchange membranes (one cationic, and one anionic). The cation exchange membrane is next to

The ability of an osmotic membrane to selectively allow solvent molecules to pass, while blocking solute ions, can be utilized to generate a hydrostatic pressure. With pure water and seawater, the osmotic pressure could theoretically raise the seawater solution to a height of 240 m (more than three times the height of Niagara Falls). This hydrostatic 'head' can be used to drive a hydroelectric turbine, or alternately, the pressure can be used directly in a pressure-retarded osmosis cell.





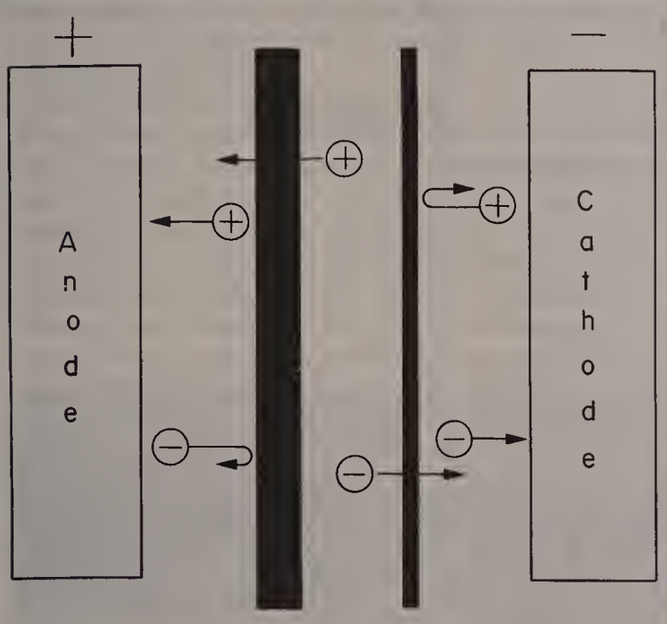
the cathode, and the anion exchange membrane next to the anode. For electrodialysis to occur, the power supply is connected to the electrodes, and electrolyte is allowed to flow between the two membranes. The electrolyte becomes diluted in the compartment between the two membranes, as cations go through the cation exchange membrane into the cathode compartment and as anions go into the anode compartment. The concentration of electrolyte in these two outer compartments consequently increases to well above that in the central compartment.

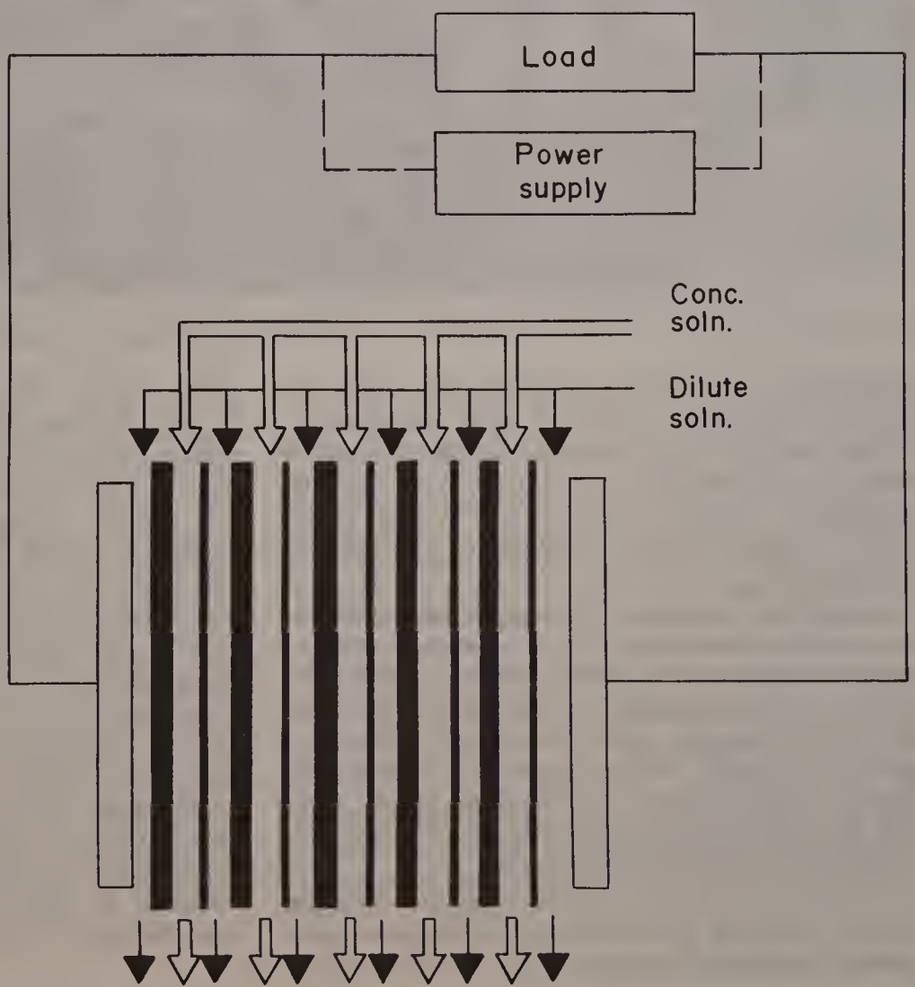
Once a concentration difference has been produced, power can then be generated by an electrodialysis cell (which is now an R.E.D. cell) if the electrodes are reversible.

Otherwise, part of the energy would be expended in producing hydrogen and chlorine at the cathode and anode (with a seawater electrolyte). It can be calculated that 100 membrane pairs in series between two reversible electrodes can give around 6 V under load.

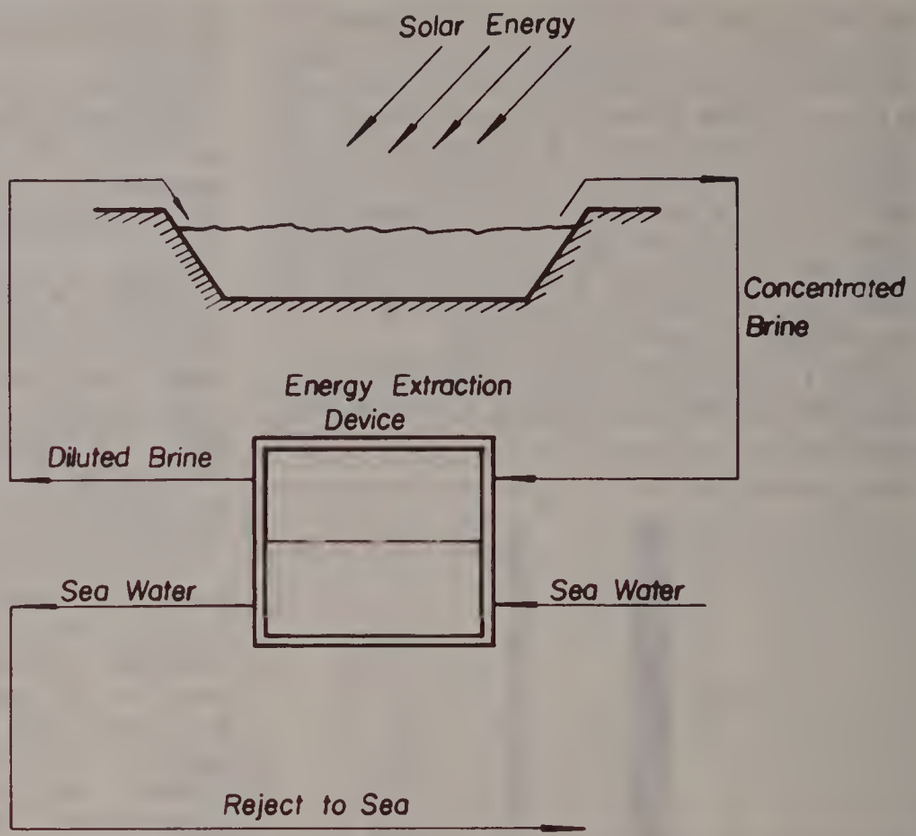
Buildup of concentration gradients around the membranes is reduced within manageable limits by natural convection and, if necessary, by a low power pump. Convection causes the depleted, less dense, saline solution to rise through the membrane stack spaces. It is believed that natural convection will be rapid enough to avoid concentration polarization, but electrolyte can be pumped at very little cost to the available power output.

Various applications of R.E.D. have been suggested and may already be viable. In highly populated islands or coastal areas with secondary treatment of sewage outfall, an R.E.D. cell bank might be able to produce power at no more than $0.10/kWh using low salinity treated sewage and seawater. For Vancouver, British Columbia (Canada), the average throughput is 86 million gallons per day. With secondary treatment 1 - 2 MW could be generated; enough to run the sewage plant and supply some power to the electricity grid. Suitable city sites that immediately spring to mind are Los Angeles, noted for its heavy use of water, Tokyo, New York, Rome and generally the Eastern Seaboard of the United States and the North Western European Coast. The need, and consequently the cogency of the argument for adoption is probably greatest in cities like Hong Kong and Singapore. In





The most advanced method for utilizing salinity power is by Reverse Electrodialysis (R.E.D.). The simplest R.E.D. cell would contain a cationic and anionic exchange membrane. Each selectively allows either positive or negative ions to diffuse through the membrane. Many alternating pairs of anion exchange membranes (depicted here by thick lines) and cation exchange membranes (thin lines) would be used to make a practical battery. About one hundred membrane pairs would produce 6 volts, when the battery provides power to an external load. If the electrodes are reversible, an external power supply could be connected to the unit to generate a concentration difference by electrodialysis.



Evaporation of seawater in salt ponds (such as the one shown here in the Thar Desert) provides a concentrated salt solution which can be used for power generation by reverse electrodialysis. Seawater would comprise the other (dilute) feed solution. The salinity difference between the two solutions provides the source of Free Energy which is converted to electric power by reverse electrodialysis. Salt would be recycled, or some might be recovered as a byproduct.

these cities, an R.E.D. installation might provide complete recycling of water and sewage nutrients, as well as power, for agriculture. To the mixture of seawater and sewer water produced by the R.E.D. Installation, small amounts of KNO_3 and $FeSO_4$ could be added to make hydroponic solutions for plant growth.

Reverse electrodialysis has even greater potential for underdeveloped areas. The northwestern coast of North America receives 2500 to 4000 mm of rainfall per year. Its many streams and rivers often flow into the ocean through fiords completely devoid of human habitation. Without interfering with Pacific Salmon spawning stocks or navigation, at least up to 10% of the flow could be used. For British Columbia alone, 3500 MW could be generated.

Tropical rainfall can provide even greater potential sources of energy. Areas out of the monsoon region, such as Central and South America should abound in good sites. In monsoon areas, however, vast differences in water course levels from the dry to rainy season present a storage problem which might be nearly insurmountable. But for pond fish farmers in the coastal regions of Indonesia, reverse electrodialysis should be very welcome. Units of about 100 Watt size with attached storage batteries could use pond water overflow and ocean water as the salinity pair. Energy produced would be used for pumping; valve opening; electronic surveillance of water level, oxygen content and pH; with surplus capacity for night-time electric lighting. Further, the membranes could be bought in bulk, made into envelopes and mounded in stacks with local materials as a cottage industry. Since membranes need only be changed every five years, there would be time for villagers to acquire skills needed for efficient manufacture of replacement membranes.

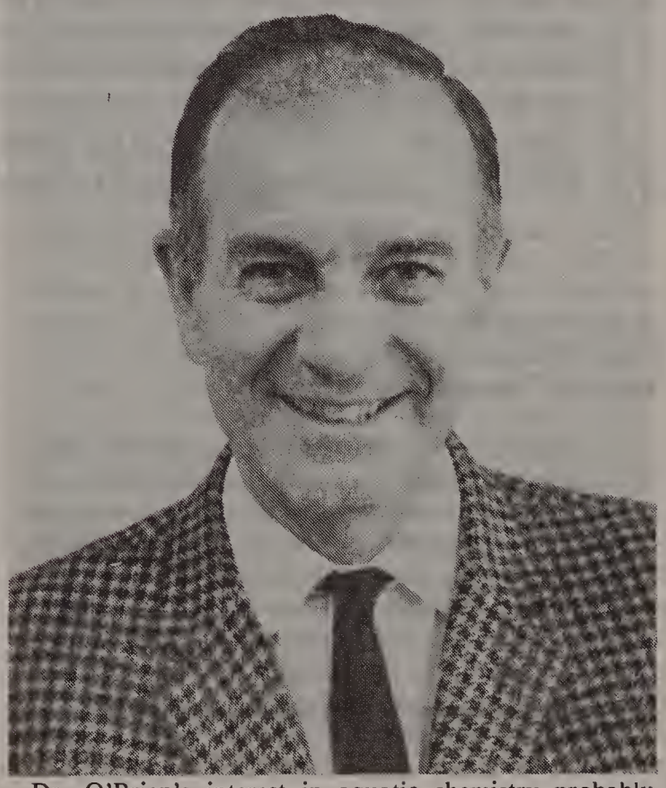
It is easy to see R.E.D. applications in areas of sufficient rainfall, but there are also possibilities in the arid seacoast regions such as Baja California, the Red Sea and the Persian Gulf, to name a few. In some of these potential sites, reverse electrodialysis may not be economic until local oil supplies are exhausted. Many areas are known to have vast salt deposits which could be dissolved in sea water to produce a highly concentrated solution, which could be used in a R.E.D. unit with seawater serving as the dilute feed solution. Salt lakes abound in many areas, and wherever salt is produced from seawater a concentrated brine is available. Some natural depressions near seawater, notably the Quatar Depression in Egypt, could be used as solar salt ponds. Then, solar energy could be harnessed to produce concentrated saline solution for reverse electrodialysis, with recycling of the salt.

In all three sites mentioned, there are extensive low dune-covered coastal areas and good protection from ocean storms. Very little effort would be required to construct shallow solar ponds fed at high tide through a gating system. Solar salt could be produced, and the remaining highly concentrated electrolytes used with seawater as feed solutions for reverse electrodialysis. Or, if a salt harvest is uneconomic, then sea water could be evaporated to about 5M NaCl concentration and used entirely for power generation. Then, about 5 kWh of power could be generated from each cubic metre of salt brine and cubic metre of seawater. With the power produced by reverse electrodialysis, potable water could be produced by electrodialysis (the so-called osmionic process, which uses no electrodes, was developed 20 years ago). Clearly, R.E.D. and a solar salt pond are a formidable pair in desert coast, and might make life easier for populations of arid coastlines.

Perhaps the most sophisticated of all applications is the adaptation of E.D.-R.E.D. for storing energy by electric utilities. It cannot compete with older methods if geographical conditions are favourable for pumping water to hill-top lakes for later hydroelectric generation, or storing compressed gas in subterranean caverns (as is now being investigated by the US Dept. of Energy). With these methods, the efficiency with which power is returned can be 55%. However, such geographical features are not accessible to many cities. It is not surprising that the Canadian government is investigating reverse electrodialysis energy storage. About 5 kWh can be stored by producing a cubic metre of concentrated LiCl solution by electrodialysis during slack demand periods, and generating electricity by reverse electrodialysis when needed. The city of Vancouver, British Columbia, could generate its entire 300 MW extra demand for electricity during the peak consumption period (5 - 8 PM) by storing 10^3 MWh electricity in a LiCl pool only 300 m long, 300 m wide and 1 m deep. The shallow pool would also act as a solar pond so that the concentrated solution would be both heated and evaporated to increase its energy content. The dilute solution could be covered with a monolayer of octadecanol to prevent evaporation, allowing in diluting rain water and solar heating. So again, reverse electrodialysis seems to be a viable route for the utilization of solar energy.

About the authors:

Robert O'Brien has led an active career touching upon many areas in chemistry and related fields. Although he is Professor of the Chemistry Department of the University of Victoria (Canada), he did not receive his formal training in chemistry. Rather, his bachelors degree was in Chemical Engineering; and his masters and doctorate work were in Metallurgical Engineering and Metallurgy. Prior to this academic training, Dr. O'Brien's experience included dropping troops and supplies in Burma during the Second World War. While undertaking his Masters Degree, he spent his weekends as Leader of a squadron of Mustang and Vampire aircraft of the Royal Canadian Air Force. In 1952, he graduated into his PhD work, and into Meteor jets. He still holds a private pilot's licence, but spends more time on the ground with his 5 children, sailing, swimming, canoeing and other sports.



Dr. O'Brien's interest in aquatic chemistry probably reflects his lifelong proximity to the sea. He grew up within a mile of the seafront on the East Coast of Vancouver (both his parents were born on Vancouver Island). While he was an optical and electrochemical consultant to the Seawater Conversion Laboratory at Berkeley (California, USA), he met Chaim Forgacs, who was then on sabbatical.

Chaim Forgacs has made major scientific and technological achievements contributing to the understanding of membrane polarization. He invented the pulse method for scale prevention and polarization control in electrodialysis units, and the high-temperature process for seawater desalination. He constructed compact electrodialysis equipment, developed industrial separation methods based on electrodialysis (for sweetening of citric juices and separation of electrolytes from organic compounds), and developed electrodialysis units for industrial waste recovery.

Dr. Forgacs performed much of his work abroad. In 1969 - 71, he was a Visiting Research Associate at the Seawater Conversion Laboratory of the University of California (USA). For four months in 1978, he undertook a lecture tour in Japan. During his sabbatical last year, he worked with Prof. O'Brien at the University of Victoria. Dr. Forgacs is presently Assistant Director of the Research & Development Authority of Ben-Gurion University of the Negev.

Recent studies probe molecular structure with neutrons

Most chemists are aware of the enormous contribution of x-ray crystallography in elucidating molecular structure, intramolecular distances and bond angles in crystalline materials. But the equally impressive utility of neutron crystallography is often not appreciated. New types of information can be obtained by neutron scattering experiments, either alone or in conjunction with x-ray data.

An increasing number of chemists are already using neutron scattering to examine molecular structure of inorganic complexes, organometallic compounds, biological macromolecules, and compounds bound to catalyst surfaces. Even greater information and faster collection of data will be possible when high intensity neutron sources now under construction are completed. Then, more opportunities will be open for all chemists to use neutron scattering as a standard technique for probing molecular structure.

by Dr. Jack M. Williams,
Senior Chemist, Chemistry Division
Argonne National Laboratory

The properties of matter in condensed states (crystalline or amorphous solids, and liquids) are of enormous importance in technology and everyday life. Building materials, natural and synthetic fibers, metals and alloys, semiconductors, dyes, adhesives, energy-storage devices and heterogenous catalysts come to mind. All biochemical phenomena take place in liquid media or at solid surfaces. A detailed knowledge of the properties of condensed matter can result from a determination of the positions and movements of the atoms in such materials. The scattering of radiation is one of the most effective experimental means of acquiring such information.

When radiation passes through matter, it is scattered by the atoms with a certain probability (scattering amplitude). When the wavelength of the radiation is of the order of magnitude of the interatomic distances (one to several angstroms), the scattered radiation undergoes constructive and destructive interference at different scattering angles. From the angular distribution of scattered radiation (the diffraction pattern), information can be derived about the spacing between atoms and the structure of the compound.

Monochromatic x-ray sources with wavelengths of around 1 Å have long been used for this purpose, but present several major disadvantages. X-rays are scattered by electrons, so the x-ray scattering amplitude of an atom is proportional to its atomic number. For hydrogen in particular, x-ray scattering is practically insignificant. Using x-ray scattering, the precise locations of atomic nuclei can be derived only indirectly from the distribution of electrons, which is generally not symmetrical about nuclear locations.

Furthermore, x-ray radiation is capable of damaging chemically-fragile materials, as its energy is comparable with the electronic excitation energies of atoms. Normally stable biological macromolecules are often damaged by x-rays. In such systems ten or more sample crystals are typically needed to collect data often amounting to 10,000 - 30,000 x-ray reflections or more. In scaling the data from different crystals and correcting for radiation damage, errors are often introduced.

In recent years, increasing attention has been drawn to thermalized neutrons as a radiation source for probing molecular structure. Such neutrons have a kinetic energy of several hundredths of an electron volt, which is about 100,000 times less than x-ray photons and hardly enough to break even the weakest chemical bonds.

Neutrons propagate with a wave-like character, as was first demonstrated in 1936 by the diffraction of neutrons impinging on a crystal. The tendency of neutrons to exhibit wave motion, rather than behave simply as a classical particle, was an early triumphant confirmation of quantum mechanics. In accord with the de Broglie equation, a neutron (like any moving particle) has a wavelength which is inversely proportional to its momentum. Thermal neutrons produced by a nuclear reactor, and selected using an appropriate monochromator crystal, have a wavelength of about 1 Å which is ideal for probing molecular structure in neutron scattering experiments.

The diffraction of neutrons differ, however, from the diffraction of x-rays in that neutrons are scattered by the *nuclei* of target atoms—and not the electrons. This is a distinct advantage in many neutron scattering experiments, as it allows the positions of atomic nuclei to be precisely located in the molecular structure, rather than inferred from the distribution of electrons. In some ways, x-ray and neutron scattering data augment each other. Comparison of both types of results allows the experimenter to resolve how the distribution of electrons deviates from simple spherical symmetry about the respective nuclei.

Thus, the two scattering techniques can together illuminate chemical bonding interactions.

Neutron crystallography utilizes a reactor source to generate an essentially monochromatic beam of neutrons which bombard the sample. Some neutrons are scattered coherently (in phase with one another) and elastically (without change in energy). The scattering amplitude of each nucleus depends upon its particular type; different nuclei vary by a factor of only 2 or 3. Unlike with x-rays, neutron scattering amplitudes do not increase in a regular manner with the atomic weight of the element. Hydrogen atoms can be located by neutron diffraction as readily as heavier nuclei. In general, neutron scattering is far superior to x-ray scattering for locating light atoms in the presence of heavier ones.

Equally important, atoms of similar atomic number often differ considerably in neutron scattering amplitude—even for isotopes of the same element. Common nuclides such as ^{14}N, ^{12}C and ^{16}O can be distinguished by neutron scattering, while their behavior towards x-rays would be nearly the same. A unique feature of neutron diffraction for structural analysis is the large difference between the coherent scattering amplitudes of hydrogen and deuterium. The scattering amplitude for deuterium is twice that for hydrogen. Moreover, a phase change of 180° accompanies scattering from deuterium (as for most nuclides) whereas no phase change occurs for hydrogen. As a result, of these factors (in addition to the much lower incoherent background scattering from deuterium) isotopic enrichment with deuterium generally causes a substantial increase in neutron diffraction intensities and improved resolution of nuclear positions. In fact, the power of neutron scattering for the study of biological materials depends to a considerable extent on the ability of the experimenter to introduce deuterium into these materials. That ability is likely to be enhanced by newly developing techniques in genetic engineering and tissue culture growth.

While positions of nuclei in molecular crystals are obtained by neutron crystallography, a different type of information is gained by neutron spectroscopy. Here, impacting neutrons transfer energy to the molecular crystal, exciting molecular vibration and rotation. Neutrons are scattered at wavelengths above or below the wavelength of the incident neutrons. The shift in wavelength reflects energy absorbed from, or transmitted to, the molecular system by the incident neutrons. Energy transfer by impacting neutrons allows the detection of low-energy molecular transitions, which are not observed by the common spectroscopic methods of infrared absorption or Raman scattering.

Neutron spectroscopy utilizes neutrons which are scattered incoherently from target nuclei, with no interference effect. The change in velocity of a beam of monochromatic neutrons corresponds to changes induced in the rotational, vibrational or torsional motions of atoms in the sample. Incoherent scattering can be especially useful for studying hydrogen-containing compounds absorbed on surfaces. This is because hydrogen nuclei cause far more incoherent scattering than most other nuclei.

Particular applications of incoherent neutron scattering are the dynamics of hydrogen bonding in solids, the structure and dynamics of hydrogen-containing materials absorbed on solid surfaces, and reorientation of ions and molecules in crystals. This promising technique has as yet been relatively little explored, but will become more practical with the advent of intense pulsed neutron sources and further development of automated systems for collecting large quantities of data. Important advances are also being made in techniques for detecting neutrons. These will extend the capability of moderate-flux neutron sources, and allow hitherto impossibly difficult experiments to be performed when new high-flux sources are introduced.

Until very recently, the main sources of thermal neutrons of sufficient flux for diffraction and spectroscopic studies have been nuclear reactors. The nuclear fission reaction produces neutrons with high kinetic energies. These are normally slowed by multiple collisions with atomic nuclei of the moderator material before their escape from the reactor. The transfer of momentum from high-speed neutrons is often greatest for collisions with low-mass nuclei, and for this reason, elements of low atomic weight (usually, deuterium or carbon) are generally used for moderators in nuclear reactors.

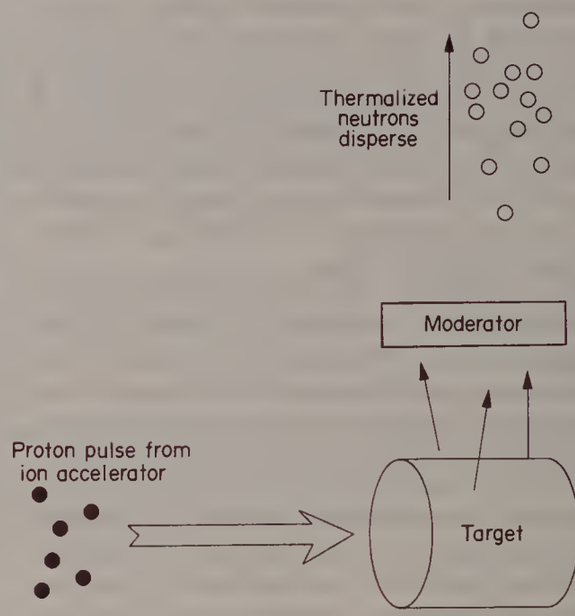
After a sufficient number of collisions, neutrons attain thermal equilibrium with the moderator material. Such "thermal" neutrons leave the reactor with a distribution of energies peaking at a value kT (where T is the temperature of the moderator, and k is the Boltzmann constant). For a moderator at about 40°C, thermal neutrons exit the reactor with velocities of several thousand metres per second. The momentum of these neutrons corresponds to a wavelength of about 1 - 2 Å, which is well suited for ordinary neutron crystallography.

For special purposes, higher neutron velocities (corresponding to a wavelength of about 0.5 Å) may be desired. The intensity of neutrons at this appreciably higher energy can be enhanced by embedding in the moderator a thermally insulated hot source (an externally heated graphite block) facing the beam port. Similarly, the intensity of "cold" neutrons can be augmented by introducing into the moderator a cold source consisting of a thermally insulated vessel filled with liquid deuterium. Neutrons of long wavelengths are useful in examining structures of macromolecular dimensions such as conformation in polymer chains, repeat distances in large biological molecules, and polyatomic clusters in alloys.

Once the moderator conditions are optimized for producing neutrons of the desired velocity, a means must be found to determine the precise velocity distribution to be used in the measurement. This has generally been accomplished by selecting neutrons diffracted from a crystal at a specified Bragg angle. Recently, however, there is growing emphasis on neutron time-of-flight methods. With a reactor, these utilize a "chopper" to produce pulses of neutrons which travel down a suitably long path for faster neutrons to race ahead, and slower neutrons to lag behind. The actual distribution of velocities can be determined by measuring the intensity of neutrons according to their time-of-arrival at the detector.

With present nuclear technology, neutron flux levels cannot be raised much higher than those

High-intensity neutron pulses will be produced using high-energy particle accelerators. The accelerator will release a burst of protons with energies of about 10^9 eV, causing neutrons to be liberated by spallation from a heavy metal target. As many as 30 neutrons can be ejected for each incident proton. The neutrons are ejected with high energy, and must be slowed down to near thermal energy before they can be used for neutron scattering experiments.



presently produced by the high-flux reactors in the United States and Europe (about 10^{15} neutrons/cm^2 sec). The constraints of heat removal and fuel cost place a limit on the neutron flux which can be achieved in the core of a reactor. However, in the last few years, a new type of pulsed source has been developed. In this device, neutrons are produced by the impact of an accelerated beam of high-energy protons (about 1GeV energy) on a heavy-metal target. Several tens of neutrons are released by the impact of each proton. This new generation of neutron sources offers the prospect of effective slow-neutron fluxes which are higher than can be achieved with present reactor technology. Higher instantaneous fluxes can be produced than in steady (nuclear reactor) sources because heat removal restrictions, which limit reactor fluxes, are relieved by the pulsed operation: the source is "on" only a small fraction of the time and the spallation process at the target requires dissipation of a relatively small amount of heat per neutron produced.

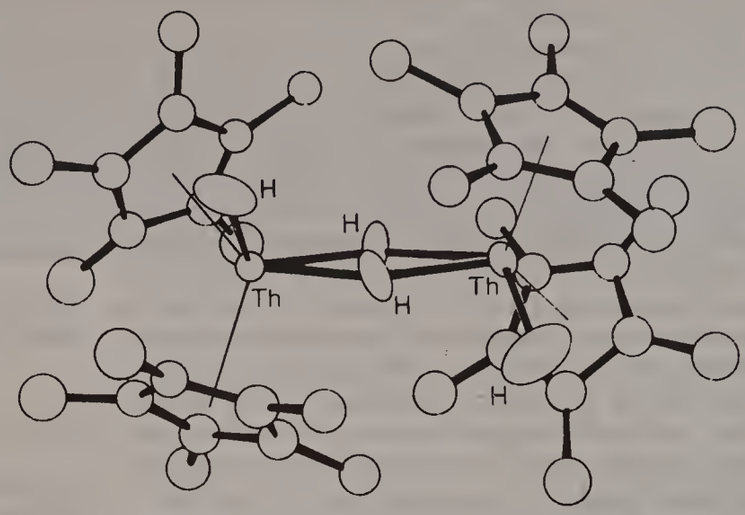
Because of the pulsed nature of the neutron source, the neutron beam is already prepared for time-of-flight velocity analysis and neutrons can be used more efficiently than those from reactors. The use of time-of-flight methods in conjunction with production of neutrons by spallation will make possible much-improved resolution and intensity for many types of neutron experiment. A large-scale prototype is now in operation at Argonne National Laboratory in the USA. It produces five neutrons beams, each with a peak thermal neutron flux of about 10^{14} neutrons/cm^2 sec. To be completed in early 1981 is the Intense Pulsed Neutron Source I-a fully-instrumented device with twelve neutron beams and a peak thermal neutron flux of 10^{15} neutrons/cm^2 sec. A design has been completed for an even larger device, able to produce 60 pulses per second of neutrons with a peak flux of about 10^{16} neutrons/cm^2 sec. Another source approaching this intensity, the Spallation Neutron Source (SNS), is already under construction at the Rutherford Laboratory in England.

The high cost of facilities and associated instrumentation for neutron-based research limits the number of institutions capable of supporting such research. Furthermore, a limited number of experiments can be conducted at each facility, as the experiments are often slow to conduct. Often, one to three weeks of data collection is required for a single sample.

In the United States, twelve neutron source reactors are in operation at several national laboratories. In Europe, an institution dedicated to neutron-scattering research is supported jointly by France, the Federal Republic of Germany and the United Kingdom. This is Institut Laue-Langevin in Grenoble (France), which has an in-house staff of eighty scientists and provides annually for 1500 investigators working on 700 projects. The number of applications for use of facilities at the Grenoble installation has grown enormously from about 30, when reactor operation began in 1972, to more than 400 per six month period.

A new reactor devoted especially to neutron-beam work was commissioned in France last year. In the Federal Republic of Germany, a study has just been completed for a new medium-to-high-flux beam reactor and will be discussed against an alternative proposal for a spallation neutron source. In the United Kingdom, the Spallation Neutron Source at the Rutherford Laboratory has been funded as discussed above. A new high-flux beam reactor, comparable to the high-flux beam reactor at Grenoble, will be commissioned in the USSR in the early 1980's. Plans for pulsed neutron sources are well advanced at Argonne National Laboratory and Los Alamos Scientific Laboratory in the United States, and at the High Energy Physics Institute in Tsukuba, Japan, as well as for the pulsed reactor at Dubna in the USSR.

Organometallic complexes of lanthanide and actinide elements offer unique features, which are only now being explored. Recent synthesis of the first organometallic thorium complex was followed by determination of its unusual structure with neutron diffraction. These studies showed that the complex has two kinds of thorium - hydrogen bond: a simple bond to terminal hydrogen atoms (2.03 A long), and a double hydrogen bridge (with a bond length of 2.29 A) that evidently exists in place of a metal - metal bond. The hydrogen bridge between the two thorium atoms has a surprisingly small thorium - hydrogen - thorium bond angle of 58°.

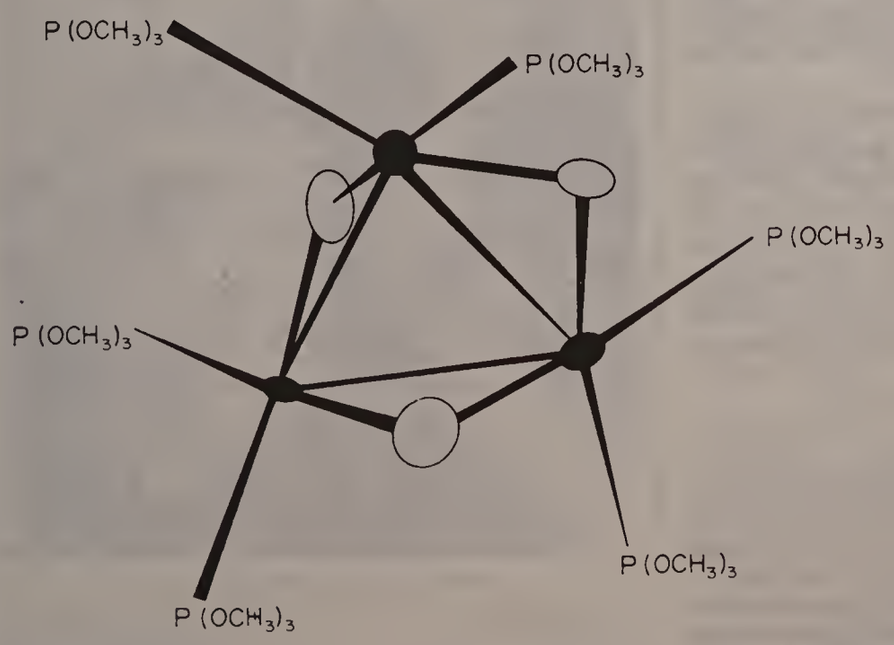


The unique power of neutron-scattering measurements in solving chemical problems is illustrated by examples of recent research drawn from diverse fields. Hydrogen bonding in crystalline materials is particularly apt because neutron diffraction, unlike x-ray diffraction, is capable of directly locating the bonding hydrogen atoms. Thus the complete geometry of the bond can be established and inferences drawn relating to the bond strength and effects of the environment.

Of equal interest are recent studies of hydrogen bound to transition-metal complexes. Many of these compounds are homogenous catalysts for hydrogenation and dehydrogenation reactions, while others serve as models for heterogenous catalysts. By locating hydrogen atom positions in relation to the metal atoms, neutron diffraction has established that the hydride ligand—despite its small size—often occupies a metal coordination site with a normal bond length. However, hydrogen atoms are also capable of bridging two metal atoms, as has been observed in several examples of organo-metallic complexes.

The first known organometallic actinide was synthesized in 1978, and its structure has been determined by "direct-methods", using single-crystal neutron diffraction data only. The power of neutron crystallography was dramatically shown by the ability to precisely locate hydrogen atoms adjacent to heavy thorium atoms in the large molecule. Interestingly, the molecule, a crystalline dimer of bis(pentamethylcyclopentadienyl) thorium dihydride, has two different kinds of thorium - hydrogen bonds: a bond from each thorium atom terminating at a hydrogen atom, and bridging bonds to two hydrogen atoms separating the thorium atoms. Metal - metal bonding is apparently obviated by the presence of the double hydrogen bridge, as the 4.007 Å thorium - thorium distance in the complex is appreciably greater than the 3.59 Å bond distance in thorium metal. Curiously, the hydrogen atoms in the two bonding environments can exchange positions fairly readily.

This compound is only one example of many actinide and lanthanide complexes which are likely to come under study. Uranium forms a similar compound, the structure of which has yet to be analyzed. Organometallic chemistry of actinides and lanthanides, involving possible combinations of *f*-type orbitals not encountered with other elements, is a promising new area of research to which neutron studies surely will contribute.



Per(phosphite) cluster complexes, for which a general synthesis has recently been developed, are uniquely active catalysts for olefin hydrogenation. The complex shown here is the first whose structure was clarified by a comprehensive neutron diffraction study. A triangular rhodium atom array is the basis of the cluster framework with each rhrodium atom (shown black) bonded in approximately square planar fashion to two terminal $P(OCH_3)_3$ groups and two bridging hydrides (shown white). The positions of nuclei are depicted with their associated thermal vibrations, represented here by ellipsoids enclosing 50% probability.

An area of vast technological and economic importance is heterogenous catalysis, as witness the catalyzed "cracking" of petroleum to yield various hydrocarbons with desired characteristics, reduction of carbon monoxide with hydrogen to yield methanol or hydrocarbons, hydrogenation of vegetable oils to yield solid fats, and many other large-scale applications. In many of these surface-catalyzed reactions, carbon - hydrogen - metal interactions appear to predominate, but despite much effort, the theory of such interactions and of heterogenous catalysis in general is poorly understood. Neutron scattering has recently proven itself a valuable technique for structural studies of carbon - hydrogen - metal interactions, for both transition metals and lighter main-group metals noted for catalytic activity (lithium, aluminum, and alumino-silicates such as zeolites).

Neutron scattering has also become an important technique for the study of a novel class of metal-cluster compounds of nickel and rhodium. These show selective homogenous catalyst activity towards certain hydrogenation and cyclopolymerization reactions of unsaturated hydrocarbons. Such compounds also serve as models for chemisorption and heterogenous catalysis at the surface of the metals and their complexes in bulk. The structure of the rhodium hydride cluster $\{HRh[P(OCH_3)_3]_2\}_3$ has been determined in detail by neutron diffraction, establishing the inherently square-planar character of each rhodium atoms coordination geometry in this compound. This compound and others related to it are active catalysts for olefin hydrogenation.

Chemical studies of biological interest are particularly amenable to analysis by neutron scattering because of the ubiquity of hydrogen atoms and the importance of hydrogen bonding. Resolution can be enhanced by deuterium substitution because of a difference in magnitude and phase between coherent scattering amplitudes of hydrogen and deuterium. Nitrogen atoms can likewise be more readily distinguished from carbon and oxygen, than would be possible by x-rays. Furthermore, many biological structures display long-range order over distances greatly exceeding atomic dimensions, and these can be studied by low-angle scattering of long-wavelength neutrons from a cold source. Radiation damage to the sample, a source of great difficulty with x-rays, is practically negligible with thermal neutrons.

Progress on neutron studies applied to biological problems has been slow because of the comparatively low neutron fluxes hitherto available. This has necessitated the use of large crystals which are difficult, if not impossible, to grow. The advent of highly sensitive automated position-sensitive detectors and of intense pulsed neutron sources will be of immense value to future research in this field.

Further information:

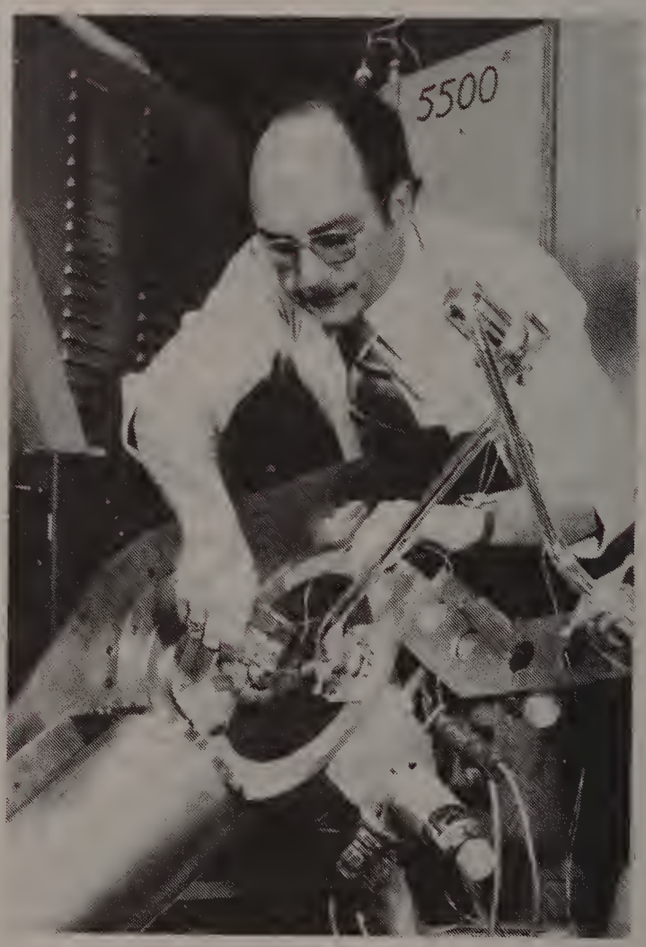
An excellent manual of techniques and applications of neutron scattering is *Present Needs and Future Trends in Neutron Crystallography and Spectroscopy,* a 94 page report based upon a National Science Foundation-Dept. of Energy workshop held in November 1978 at Argonne National Laboratory. The report was written by approximately 40 scientists, was edited by Drs. Jack Williams and Martin Paul, and is the source on which this article is based. It is not a comprehensive review of neutron scattering experiments, but is intended for research scientists at every level who are concerned with up-to-date problems involving molecular structure and dynamics in condensed states, but who may be unfamiliar with neutron scattering methods. Copies of the report are available at no charge from Dr. Jack M. Williams, Chemistry Division, Argonne National Laboratory, Argonne, Illinois 60439, U.S.A.

Acknowledgement:

The author wishes to acknowledge funding by the US Department of Energy and National Science Foundation.

About the author:

As Senior Chemist in the Chemistry Division of Argonne National Laboratory, Jack Williams is presently tackling a wide variety of neutron crystallography problems in collaboration with about 20 university investigators. He has been with Argonne National Laboratories since 1966 as a Postdoctoral Fellow, Assistant Chemist, Associate Chemist, Chemist, and Senior Chemist since 1977. In 1980, he is chairman of the Gordon Research Conference on Inorganic Chemistry. Recent visits abroad to deliver plenary lectures have taken him to Australia, France, Italy, Yugoslavia and Poland. From 1974-1978, he won awards to participate in NATO Advance Study programs dealing with "Direct Methods in Crystallography", "Chemistry and Physics of One-dimensional Metals", and most recently, was plenary lecturer at the NATO Advanced Study Institute on "Molecular Metals". In addition to his work in neutron crystallography, Dr. Williams is also interested in chemistry and architecture of the hydrogen bond, solid-state chemistry of inorganic salts with high electrical conductivity, and model homogenous catalysts.



CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1980

CATALYSIS

June 30-July 4. 7th Int'l Congress on Catalysis. Tokyo, Japan.
(Prof. I. Yasumori, Dept. of Chemistry, Tokyo Institute of Technology, 2-12-1 Ookayama, Megmo-ku, Tokyo 152, Japan)

MACROCYCLIC LIGANDS

July 3-5. Symposium on Macrocyclic Ligands. Basel, Switzerland.
(Prof. T. A. Kaden, Institut für Anorganische Chemie der Universität Basel, Spitalstrasse 51, CH-4056 Basel, Switzerland)

COORDINATION CHEMISTRY

July 7-11. 21st Int'l Conference on Coordination Chemistry. Toulouse, France.
(Prof. F. Gallais, Laboratoire de Chimie de Coordination du CNRS, BP 4142, 205 Route de Narbonne, F-31030 Toulouse Cedex, France)

CARBOHYDRATE CHEMISTRY

July 7-11. 10th Int'l Symposium on Carbohydrate Chemistry. Sydney, Australia.
(Prof. S. J. Angyal, School of Chemistry, University of New South Wales, PO Box 1, Kensington, New South Wales 2033, Australia)

PHOTOCHEMISTRY

July 13-19. 8th Symposium on Photochemistry. Seefeld, Austria.
(Prof. J. Schantl, Institut für Organische und Pharmazeutische Chemie, Universität Innsbruck, Innrain 52a, A-6020 Innsbruck, Austria)

ANALYTICAL CHEMISTRY

July 20-26. SAC 80: Int'l Conference on Analytical Chemistry. Lancaster, UK.
(Dr. J. D. R. Thomas, Dept. of Chemistry, UWIST, King Edward VII Avenue, Cardiff CF1 3NU, UK)

FERMENTATION

July 20-27. VI Int'l Fermentation Symposium. London/Ontario, Canada.
(Prof. J. E. Zajic, Faculty of Engineering Science, University of Western Ontario, London, Ontario, Canada N6A 5B9)

RAMAN SPECTROSCOPY

August 4-9. VII Int'l Conference on Raman Spectroscopy. Ottawa, Canada.
(Prof. J. A. Koningstein, Dept. of Chemistry, Carleton University, Ottawa K1S 5B6, Ontario, Canada)

POLYVINYL CHLORIDE

August 10-15. 3rd Int'l Symposium on Polyvinyl Chloride. Cleveland/Ohio, USA.
(Dr. E. A. Collins, Diamond Shamrock Corporation, PO Box 348, Painesville, Ohio 44077, USA)

NON-AQUEOUS SOLUTIONS

August 11-15. 7th Int. Conference on Non-Aqueous Solutions. Regensburg, FRG.
(Prof. J. Barthel, Institut für Chemie, Universität Regensburg, Universitätstrasse 31 - Postfach, D-8400 Regensburg, Federal Republic of Germany)

PHYSICAL ORGANIC CHEMISTRY

August 17-22. 5th IUPAC Conference on Physical Organic Chemistry. Santa Cruz/California, USA.
(Prof. J. F. Bunnett, Division of Natural Sciences—II, University of California, Santa Cruz, California 95064, USA)

MAGNETIC RESONANCE

August 25-30. Int'l Conference on Magnetic Resonance. Delft, Netherlands.
(Prof. J. Smidt, Delft University of Technology, Dept. of Applied Physics, PO Box 5046, NL-2600 GA Delft, Netherlands)

THERMODYNAMICS

August 26-29. 6th Int'l Congress on Thermodynamics. Merseburg, GDR.
(Prof. Margit Rätzsch, Technische Hochschule 'Carl Schorlemmer', Leuna-Merseburg, DDR-42 Merseburg 6, Geusaer Strasse, GDR)

POLYMERIZATION MECHANISMS

September 3-5. Int'l Symposium on Polymerization Mechanisms. Liverpool, UK.
(Prof. G. C. Eastmond, Donnan Laboratories, Dept. of Inorganic, Physical & Industrial Chemistry, University of Liverpool, PO Box 147, Grove Street, Liverpool L69 3BX, UK)

MEDICINAL CHEMISTRY

September 2-5. 7th Int'l Symposium on Medicinal Chemistry. Torremolinos, Spain.
(Prof. R. Madroñero, Sociedad Española de Química Terapéutica, Juan de la Cierva 3, Madrid 6, Spain)

TOXICOLOGY OF NICKEL

September 3-5. 2nd Int'l Conference on Environmental and Occupational Toxicology of Nickel. Swansea, UK.
(Prof. F. W. Sunderman Jr., Dept. of Laboratory Medicine, University of Connecticut, POB G, Farmington, Connecticut 06032, USA)

MACROMOLECULES

September 7-13. Int'l Symposium on Macromolecules. Florence, Italy.
(Prof. F. Ciardelli, Istituto Chimica Organica Industriale, Via Risorgimento 35, I-56100 Pisa, Italy)

CRYSTAL GROWTH

September 10-16. 6th Int'l Conference on Crystal Growth and (September 17-25) 4th Int'l Specialists School on Crystal Growth. Moscow, USSR.
(Dr. E. I. Givargizov, Institute of Crystallography, USSR Academy of Sciences, Leninskii Prosp. 59, SU-117333 Moscow, USSR)

BOC CONFERENCE—OXYGEN

September 15-18. 2nd BOC Priestley Conference (Theme: production, storage and transport of Oxygen in living systems and by industry). Birmingham, UK.
(Dr. John F. Gibson, Asst. Secretary (Scientific & Educational), The Chemical Society, Burlington House, London W1V OBN, UK)

POLYMER NETWORKS

September 15-20. 7th Discussion Conference on Polymer Networks. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelín, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

MARINE NATURAL PRODUCTS

September 16-20. 3rd Int'l Symposium on Marine Natural Products. Brussels, Belgium.
(Dr. J. C. Braekman, Faculté des Sciences, Avenue F.-D. Roosevelt 50, Université Libre de Bruxelles, B-1050 Bruxelles, Belgium)

NATURAL PRODUCTS

September 21-27. 12th Int'l Symposium on Chemistry of Natural products. Tenerife, Spain.
(Prof. A. G. González, Instituto de Productos Naturales, Carretera la Esperanza 2, La Laguna, Tenerife, Spain)

SURFACE CHEMISTRY

September 22-26. 4th Int'l Conference on Solid Surfaces; 3rd European Conference on Surface Science; 8th Int. Vacuum Congress. Cannes, France.
(Dr. M. Costa, Laboratoire d'Electrochimie Interfaciale, CNRS, 1 place Aristide Briand, F-92190 Meudon, France)

HETEROCYCLES

September 22-27. 21st Prague Microsymposium on Ring-Opening Polymerization of Heterocycles. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelín, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

SYNTHESIS OF NEW ELEMENTS

September 23-27. Int'l Symposium on the Synthesis and Properties of New Elements. Dubna, USSR.
(Prof. Yu. Ts. Oganessian, Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, Head Post Office, Box 79, SU-101000 Moscow, USSR)

1981

TOXICOLOGY

March 4-7. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142-144 Oxford Road, Cowley, Oxford OX4 2DZ, UK)

PARTICLE INTERACTIONS IN COLLOIDS

March 16-21. Int'l Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

MOSSBAUER EFFECT

April 13-17. Int'l Conference on the Application of the Mossbauer Effect. Srinagar, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi, 110012, India)

CHARACTERIZATION OF POLYMERS BY NMR

July. 22nd Prague Microsymposium on Characterization of Dynamic and Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlacek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovskeho n.2, CS-162 06 Praha 616, Czechoslovakia)

SURFACE AND COLLOID SCIENCE

July 5-10. 4th Int'l Conference on Surface and Colloid Science. Jerusalem, Israel
(Prof. A. Silberberg, Dept. of Polymer Chemistry, Weizmann Institute of Science, Rehovot, Israel)

MACROMOLECULAR CHEMISTRY

July 6-9. 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, 1er Étage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France)

POLYMER CHARACTERIZATION

July 13-17. Int'l Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

CAROTENOIDS

July 26-31. 6th Int'l Symposium on Cartenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, PO Box 147, Liverpool L69 3BX, UK)

ORGANOMETALLIC CHEMISTRY

August 2-6. Int'l Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, USA.
(Dr. L. S. Hegedus, Dept. of Chemistry, Colorado State University, Fort Collins, Colorado 80523, USA)

ORGANOMETALLIC CHEMISTRY

August 9-14. 10th Int'l Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

CHEMICAL EDUCATION

August 9-14. 6th Int'l Conference on Chemical Education, Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington, DC 20550, USA)

IUPAC CONGRESS

August 16-22. 28th IUPAC Congress. Probable topics are: Chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, inorganic chemistry, organic chemistry, and physical chemistry. Vancouver, Canada.
(IUPAC Congress secretariat, c/o Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

ANALYTICAL STUDIES

August 20-21. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford Street, London SE1 9NQ, UK)

NONBENZENOID AROMATIC COMPOUNDS

Aug. 30-Sept. 4. 4th Int'l Symposium on Chemistry of Nonbenzenoid Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Dept. of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

CHEMICAL PHYSICS

October 1-7. Int'l Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-6, SU-117334 Moscow, USSR)

1982

CHEMISTRY RELATING TO AGRICULTURE

February 9-12. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington DC 20036, USA)

MYCOTOXINS AND PHYCOTOXINS

August. 5th International IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. P. Krogh, Dept. of Veterinary Microbiology, Purdue University, W. Lafayette, Indiana 47907, USA)

POLYMERIZATION OF HETEROCYCLES

Summer. Int'l Symposium on Polymerization of Small Heterocycles. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, PO Box 49, Curie-Sklodowskiej 34, PL-41 800 Zabrze, Poland)

NATURAL PRODUCTS

August 20-27. 23rd Int'l Symposium on Chemistry of Natural Products. Pretoria, S.A.
(Dr. J. R. Bull, National Chemical Research Laboratory, C.S.I.R. POB 395, Pretoria 0001, South Africa)

OFF THE PRESS

Recent IUPAC publications

Proceedings; 27th Congress of Pure & Applied Chemistry

This volume includes five plenary and 31 invited lectures presented at the 27th Congress of the International Union of Pure & Applied Chemistry, held in Helsinki, Finland on 27 - 31 August 1979. Chemists from 40 countries attented the meeting to hear lectures on the most recent developments in key areas of chemistry.

The plenary lectures are entitled:

Prospects of Biotechnology in a Resource-Limited World (by E. L. Gaden Jr.)

Physical, Biochemical and Biophysical Bases for Creation of New Effective Anticancer Agents (by N. M. Emanuel)

Steroid Immunoassay in Clinical Chemistry (by D. Exley)

Fractionation and Determination of Trace Elements in Plants, Soils and Sediments (by Cottenie, Camerlynck, Verloo and Dhaese)

Glycopeptides of Human Teratoma Stem Cells (by Rasilo, Wartiovaars and Renkonen)

Invited lectures are grouped into six subject areas; Trace Element Analysis, Modern Methods in Clinical Chemistry, Analysis and Structure of Cell Membrane Carbohydrates, Chemistry and Technology of Natural Polymers and Their Degradation Products, Biotechnology and Bioengineering, and Chemometrics.

The 396 page hardcover volume, edited by A. Varmavuori and Kemira Oy, includes approximately 1200 references. It is expected to be available in June at a price of £44.50 (US $100).

Critical Survey of Stability Constants and Related Thermodynamics Data of Fluoride Complexes in Aqueous Solution

The IUPAC Commission on Equilibrium Data has published several volumes so far in the subseries "Critical Evaluation of Equilibrium Constants in Solution" within the Chemical Data Series. The present book is the third published so far on the stability constants of metal complexes. Stability constants and thermodynamic data are critically evaluated and the various techniques of determining them are assessed.

The introductory section of this 80 page volume discusses techniques for measuring fluoride stability constants, techniques for measuring enthalpies of fluoride complexation, the scope of this survey, and presentation of data and explanation of the data tables. The larger second section of the book provides data tables of stability constants, enthalpy and entropy, a summary of 'best' values, and references.

Due for publication in August, this flexicover edition will cost £11 (about US $25).

Polymeric Amines & Ammonium Salts

This book contains main lectures and contributed papers presented at the International Symposium on Polymeric Amines and Ammonium Salts, held September 1979 at Ghent, Belgium. It is a compilation of reviews and original work presented by distinguished scientists from universities and industries from all over the world. The book describes the many different ways to synthesize polymers containing amino and/or ammonium salt functions in or on polymer backbones, the physical and chemical properties of such polymers, and finally their real or potential uses in different fields.

The twelve main lectures and twenty-nine communications presented at the symposium have been edited into the 424 page hardcover volume by Prof. E. J. Goethals of the University of Ghent. The volume, due for publication in August, will be available at a cost of £37.50 (approximately US $85).

Phosphorus Chemistry Directed Towards Biology

Many of the most important molecules of life are esters of phosphoric acid: nucleic acids, metabolic intermediates, coenzymes, and carriers of energy for biochemical systems. The International Symposium on Phosphorus Chemistry Directed Towards Biology held September 1979 in Burzenin, Poland was devoted to both the chemistry and biochemistry of these phosphate esters, and in particular to methods of synthesis and detailed roles in enzymology. These invited lectures define the frontiers of modern biochemical research. Topics include the synthesis of nucleotides, sterochemistry of enzymic reactions of phosphorus, and mechanisms for chemical modes for enzyme systems.

This first symposium on Phosphorus Chemistry Directed Towards Biology was intended to help 'pure' phosphorus chemists to cross disciplinary borderlines and contribute to further developments in biologically-oriented phosphorus chemistry.

Twenty-two lectures presented at the conference are contained in this 240 page hardcover volume, edited by Prof. W. J. Stec. The book, which is expected to be published during July/August 1980, will cost £27 (about US $60).

Propylene (Propene)
Volume 7: Int. Thermodyamic Tables of the Fluid State

This book provides a detailed set of tables of thermodynamic properties of propylene. Equations used to prepare tables are also provided so that they may be used by readers. The text compares these equations with others that are available, discusses all available experimental results, and compares these results with the behavior predicted by the equations.

This 25th volume of the IUPAC Chemical Data Series is scheduled for publication in July. It is edited by S. Angus, B. Armstrong and K. M. de Reuck of the Thermodynamics Project Centre (at Imperial College, London UK). Containing about 270 pages and 58 references, the hardcover volume will cost £34 (US$75).

Where do we go from here? A few ideas for IUPAC

Some of the greatest advances in chemistry were made by those who had entered a new field, formulated a fresh outlook, and suggested new approaches which had not been considered before. Clearly, this was one of the benefits of active participation by young professional chemists at the 1979 IUPAC General Assembly. Attending various meetings of IUPAC Divisions, Commissions and Working Parties, these observers were able to learn what IUPAC was doing in their field of specialization, and often contributed their expertise to the discussions.

When asked later for their critical impressions by IUPAC President Zollinger, some interesting new ideas were contained in their replies. Perhaps one of the most interesting proposals was made by Dr. J. D. F. Ramsay of the Atomic Energy Research Establishment (like other UK observers, Dr. Ramsay attended with a grant provided by the Wates Foundation).

He discussed the valuable role played by the *Colloid & Interface Science International Newsletter* in stimulating the formation of a new International Association of Colloid and Interface Scientists (IACIS). Members of the IUPAC Commission on Colloid & Surface Chemistry made a major contribution to the creation of the new organization, using their newsletter as an information medium for events relating to surface chemistry. Preparation of the newsletter will now pass to the IACIS, who will devote one section to activities of the IUPAC Commission.

"Distribution of informal specialist newsletters concerning activities in the fields covered by individual commissions would seem a valuable feature which IUPAC is well placed to organize. Such an activity", continued Dr. Ramsay, "could also stimulate 'feed-back' on a more informal basis from chemists who are active in the range of specialities covered by the Commissions." Dr. Ramsay suggests that "these newsletters could be published and distributed by IUPAC itself or perhaps by scientific journals in (various) other countries." Although it is unlikely for IUPAC to allocate funds for the publication of newsletters during its present difficult financial circumstances, IUPAC bodies *are* well placed to seek external funding, or disseminate information about their activities through existing specialist newsletters and journals.

One example is the *International Newsletter on Chemical Education,* which has been published for some years by the IUPAC Committee on Teaching of Chemistry with a UNESCO grant. The newsletter has gained wide recognition and acclaim.

The Newsletter published by the European Photochemistry Association (an Associated Organization of IUPAC) provides a fine example of how IUPAC Commissions can publicize their activities directly to specialists in their respective subject areas. This quarterly newsletter points out recent articles, books and doctoral theses dealing with photochemistry. It provides information about forthcoming photochemistry conferences, and fellowships available for postdoctoral photochemical research. The newsletter also contains a brief report of activities and projects reported at meetings of the IUPAC Commission on Photochemistry. Through the EPA Newsletter, this highly specialized information is funneled directly to the individuals who have the greatest need and interest.

Another viewpoint expressed by observers to the IUPAC General Assembly was that greater emphasis should be placed on communication between various Commissions dealing with related subjects. "One of the most important aspects of the commission activities appeared during the joint meetings. Such opportunities are to be encouraged," urged Dr. Michel Geoffroy (of the University of Geneva in Switzerland). Dr. A. F. Williams (from the same university) elaborated. "Two subjects can be very closely related yet fall within the terms of reference of two different Commissions (an example is X-ray fluorescence and neutron activation analysis)," he explained. "I would imagine that a more fluid structure of Commissions reporting back to the main Division committee might help to avoid this (problem of lack of communication). It might equally be useful to hold general Division meetings before and after the Commission's meetings. I would prefer to see the Commission more as a study group than as a separate, rigidly defined, entity."

A similar impression was formed by Dr. B. A. Goodman (of the Macaulay Institute for Soil Research in Scotland). He wrote that "A major problem in IUPAC seems to me to be the difficulty of communicating between Commissions. . . there are instances of Commissions discussing work on a particular subject completely unaware of recommendations on that subject that had already been published by another Commission."

While meetings between related Commissions can help coordinate their activities, the large number of people participating in such joint meetings can be

cumbersome. This view was expressed by Dr. J. Buffle (from the Department of Mineralogical Chemistry of the University of Geneva), who attended meetings held exclusively by one Commission, and joint meetings held in conjunction with a second Commission. "I was very favourably impressed by the quality and precision of the work carried out by this Commission," he stated (translation). "The time taken over by discussion of each project was just about right and the amount of time wasted was reduced to a minimum." Dr. Buffle attributed this efficient utilization of time largely "to the fact that only contentious points of the projects were discussed by the Commission, the rest of the work being carried out by small groups outside the actual Commission meetings." But the use of time at the larger joint meetings was, he felt, not nearly as productive. "There is no doubt", he stated in his letter, "that the amount of time wasted increases because of the large number of people present. These meetings, although useful, should therefore in my opinion be limited to a minimum."

The paramount importance of work done outside the Commission meetings was stressed even more by Dr. A. Lindenmann of Sandoz AG in Basel, Switzerland. He thought that many subjects discussed at Commission meetings could be dealt with entirely through correspondence. He remarked (translation) that "The topics under discussion (at the Commission meeting) were dealt with too superficially, too theoretically and in an oral report which was so short as to be meaningless. To some extent, the reports of the working parties were not substantial enough (either)."

The function that Commissions could best accomplish at their meetings was touched upon by R. D. Cannon of the University of East Anglia (UK). He observed that the preponderance of Committee-like activities at the General Assembly was misleading, "since so much of the real work is done by individuals working alone at their home institutions." So what then should Commission members try to accomplish at meetings? Dr. Cannon felt that coordination of activities should be the primary goal. "An hour spent discussing who will do what, may save literally years of wasted effort. This was strikingly borne out by the joint meeting (which I attended). The two bodies compared their plans for new publications . . . and one clear case of duplication was detected and headed off before too much time had been spent."

Perhaps the most significant impressions conveyed by the observers concerned how IUPAC could broaden the participation of young chemists. After all, that was a major reason for inviting the observers, who were generally between 30 and 40 years of age. One important point was made by Dr. A. F. Williams (who was sponsored as an observer by the Schweizerisches Komitee für Chemie). He felt that a significant obstacle for the participation of young chemists in IUPAC "is that the painstaking but important work of collating data or preparing a paper for a IUPAC report does not seem to have the same academic kudos as an original piece of research. This is accentuated when the final paper carries only the name of the member of the Commission associated with the project (or even worse, the Commission chairman only). . . I feel it would be a great encouragement to younger scientists participating in IUPAC work if they could feel that IUPAC was supporting them. In view of the present pressures on young scientists seeking permanent positions, I feel that such encouragement is a necessity."

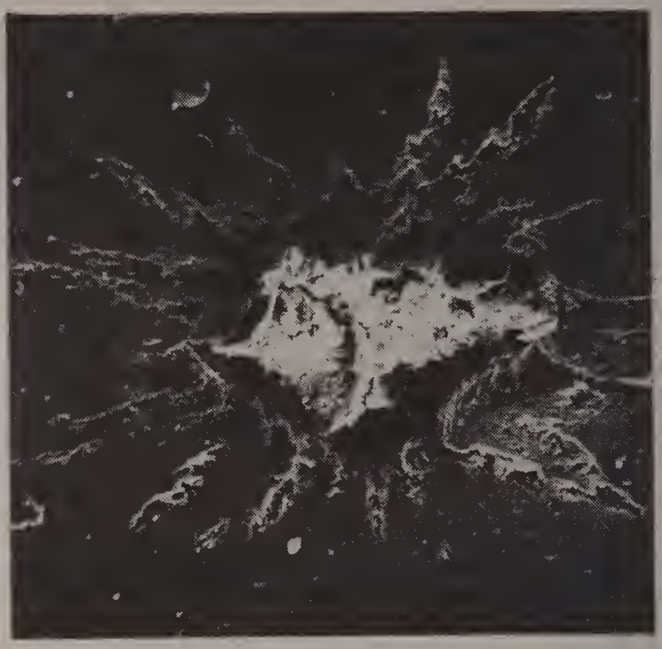
Improvements to the young observer programme itself were also suggested. Here, experiences and opinions of the observers were strikingly similar, and a simple course of action suggested to enhance the programme's effectiveness in future years. One observer remarked simply that "no one told us what we were expected to do." Another commented, "I was a little put out at the lack (in fact, complete absence) of any preliminary information. It was only on my arrival that I learned who were the members of the Commission in whose work I was to participate, and what subjects would be dealt with. An information sheet (sent in advance of the General Assembly) would have been sufficient for this."

Funding for young observers to attend IUPAC General Assemblies has been provided primarily by national organizations, although a few grants have been made by chemical companies. In the past, organizations in the UK, USA, Denmark and Switzerland have provided financial assistance and administrative help in the selection of candidates. It is hoped that further support can be obtained from other member countries to continue and expand the young observer programme at the next IUPAC General Assembly, to be held in Leuven, Belgium in 1981.

Subjects of great impact were among those discussed at the October 1979 meeting of the IUPAC Working Group on Supported Polymer Films. The group has been studying the adhesion of polymer coatings to metal surfaces and assessing the ability of anti-corrosion paints to withstand impact of small projectiles. This is especially important for automobile coatings. Small pebbles thrown from road surfaces can damage polymer paint coatings, leading to corrosion of underlying metal.

Different types of damage are inflicted on a polymer surface, depending upon the velocity of the impacting particle. This is most strikingly evident from the scanning electron micrographs presented by Dr. U. Zorll. Working in his laboratory at the Forschungsinstitut für Pigmente und Lacke e.V. (in the Federal Republic of Germany), Dr. Zorll bombarded polymer coatings with spherical particles (2 mm diameter) travelling at 100 - 300 km/hr. He found that the paint film separated completely from the underlying metal when the projectile struck at high speed. Although the coating adhered to the metal substrate at lower impact velocities, the impact stress caused a radial fracture which dissipated rapidly with distance from the point of impact.

Most surprising was the damage inflicted by a particle striking the surface at an oblique angle. The polymer coating became detached in a *circular* zone, even at impact angle of 45°. However, the shearing stress resulting from oblique impact is evident from the non-uniform damage outside the detachment zone.



Corrosion of an automobile chassis often begins when the paint coating has been damaged by pebbles and other small projectiles flung from the road surface. These photographs display a vivid close-up view of the problem. Complete detachment of the polymer coating occurs when a small particle strikes the surface at high velocity (photo above left, 25X magnification). Damage at low impact velocities results from azimuthal stress, which diminishes rapidly with distance from the impact axis (photo above right, 100X). When the particle strikes the surface at an angle of 45° (photo left, 35X magnification), the impact detaches the paint in a circular zone and shears the coating on one side.
(Photographs courtesy of Dr. U. Zorll.)

Adhesion of polymer coatings was approached from a different viewpoint by Dr. J. Sickfeld, who had constructed in his laboratory a pull-off device for evaluating polymer adhesion. Balancing this purely practical work were theoretical aspects of the pull-off test discussed by Dr. M. Biermann. His discussion will be published as an article entitled "Theorie der Abreissprüfung".

Until now, the Working Group (which forms part of the IUPAC Macromolecular Division) has been concerned with coatings on *metal* surfaces. The Group now anticipates, however, that the growing role of coated plastics in automobile manufacture will warrant attention in their future activities.

During their October meeting, held in Berlin, the Group agreed to undertake a new project entitled "Analysis of Emulsion Paints". The objective of the project will be to specify precisely the composition of emulsion paints in regard to pigment/binder ratio, binder composition and particle size distribution.

Another new project will investigate the "Stability of amino resin-containing systems". It follows the successful conclusion of two previous projects and submission of final reports on "Analysis of the functional groups in amino resins" (to be published in 1980) and "Determination of non-volatile content of amino resins" (to be published in *Journal of Applied Polymer Science).*

With great sadness, we report the untimely passing of Prof. Koichi Yamada from cancer on 28 January 1980. Dr. Koichi Yamada, Professor Emeritus of Tokyo University and the Chairman of the Japanese Association of Industrial Fermentation, had served as a Titular Member of the IUPAC Commission on Fermentation from 1975 to 1979. His contribution to IUPAC and the world community of fermentation will be long remembered.

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and appplied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

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Australian Academy of Science **(Australia)**
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Chemistry International

IUPAC

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THE EDITOR'S DESK

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Keeping the record straight for future chemistry historians

It is an unfortunate fact that scientists are much less conscious of the historical value of their personal and professional records than are their colleagues in the arts and the humanities. It is true that the basic scientific contributions of chemists are documented in perpetuity in their publications. Often however these reveal little of the circumstances under which the work was carried out and the interactions with contemporaries that led to the ideas behind the eventual publication. This will become increasingly important; younger chemists are now attuned from their early schooling to use digitized data acquisition systems of ever increasing electronic sophistication. They will find it next to impossible to reconstruct the thought processes of those who preceded them in the pre-computer age. This applies to experimentalists who nonchalently deal with masses of experimental data obtained with modern data acquisition systems, and also to theoreticians who accept for granted the powerful techniques of computer based numerical analysis.

No doubt, many chemists will feel that only vanity would induce them to have their personal memorabilia preserved in archives. Others must emphasize to them the value of their correspondence, laboratory note-books, drawings and sketches, photographs and descriptions of experimental apparatus. Such encouragement can be most effective in the years immediately preceding retirement. At this stage in their careers, many chemists undergo emotional readjustments that make such action difficult. From a pragmatic viewpoint, the reorganization of office and laboratory at retirement often applies pressures that cause chemists to consign letters and records of a lifetime to the waste paper basket. Historians and other scholars are appalled at this loss of materials that could immeasurably aid their research and understanding of the progress of science.

Up to the present time, IUPAC has not concerned itself with this problem. However, some scientific organizations in allied fields are helping to alert the scientific community to the importance of preserving personal records in archives. In the U.K., the Contemporary Scientific Archives Centre was established in 1973 with support from The Royal Society, The British Library and the Wellcome Trust, under the direction of Prof. Margaret Gowling. This active Centre maintains a small staff of professional archivists at Oxford University. It has so far collected and professionally catalogued records and correspondence of some eighty British scientists and engineers including eight chemists.

In the United States, the Center for History of Physics of the American Institute of Physics also has a group at work under the direction of Dr. Joan Warnow. Its main goal is to preserve original source materials documenting the growth and impact of physics and astronomy.

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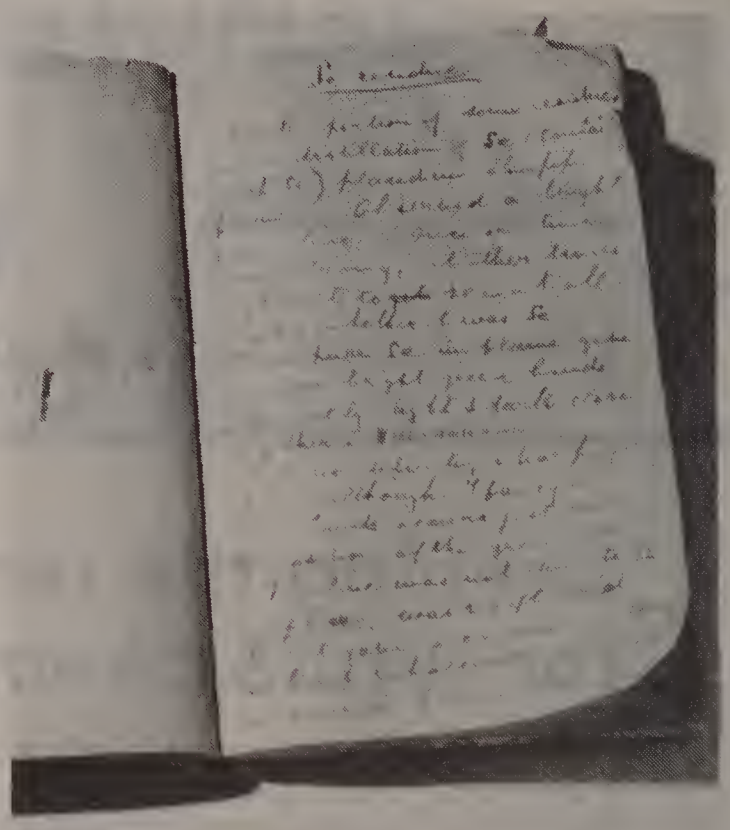
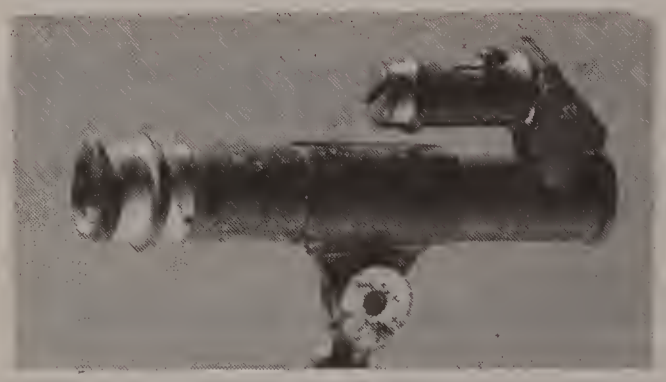
One hundred and twenty years after Sir William Crookes discovered the element thallium, his impressions at the instant of discovery can still be relived by reading his laboratory notebook. Crookes was a spectroscopist, concerned with atomic emission from flames and discharge tubes (later to be called "Crookes tubes"). In March 1861, when he recorded his observations on this notebook page, he was examining the light emission from a blowpipe flame. Into the flame he inserted a sample of metal obtained by the distillation of selenium. He examined the flame through a small spectroscope, perhaps through the viewing telescope shown here. "Observed a bright green line", he recorded. "Tried whether it was Se. Some pure Se in flame gave regular bright green bands . . . but no definite, sharp green line." He noted, "The line was not due to Se." After further experiments, Crookes could only conclude that an impurity in his sample was an element that had never before been observed *(photographs courtesy of the Science Museum, London, Crown Copyright, U.K.).*





The success of the Center for the History of Physics has inspired John Wotiz (of Southern Illinois University at Carbondale) and others to advocate creation of a History of Chemistry Center. Their proposal was accepted at a March meeting by the American Chemical Society Board of Directors. Whether the Center should operate internationally, or should restrict its role to preserving records of American chemists, has not yet been resolved. That question is expected to be clarified by August 1980. Also by that time, the level of funding should be established, a site selected for the Center, and a director appointed.

Some peripheral involvement of IUPAC in the encouragement of preserving personal records of chemists occurred during the 30th General Assembly at Davos, Switzerland in September 1979. Then, Commission I.5 on Molecular Structure and Spectroscopy endorsed the action of the Coblentz Society in establishing a Documentation Center for the History of Chemical Spectroscopy. This is located at Bowdoin College, Brunswick, Maine, U.S.A. The project is under the supervision of Prof. Dana Mayo of the Chemistry Department at Bowdoin College and the Librarian, Mr. Arthur Monke.

The Coblentz Society's Documentation Center will register the nature, location and availability of historical documents on a world-wide basis. Storage facilities will be provided at the college library for those who wish to deposit records there, or where no other provisions are available for storing the material. The Coblentz Society also plans to maintain microfilm or microfiche copies of selected materials to centralize their accessibility. At a later stage, a more professional archival service may be possible. The first objective is to communicate as widely as possible with chemical spectroscopists who have recently retired or who are approaching retirement age.

*R. Norman Jones**

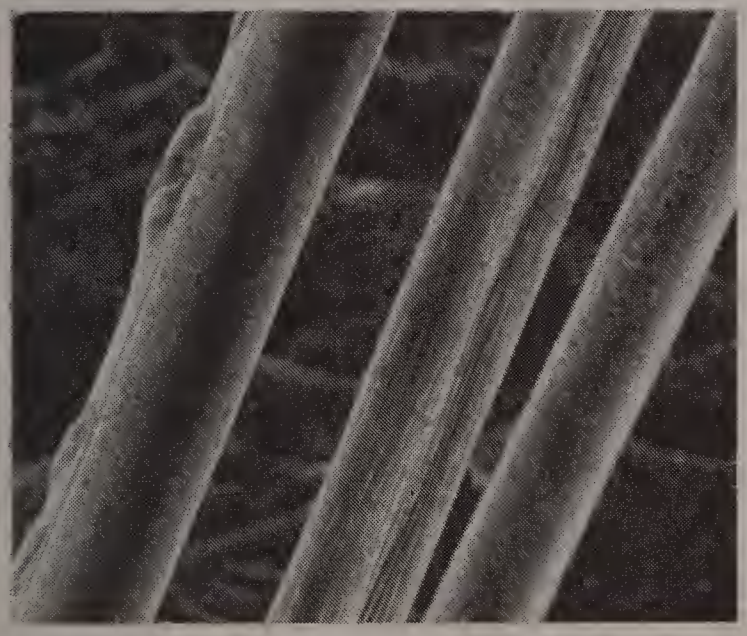
**R. Norman Jones is Visiting Professor at the Tokyo Institute of Technology and is a member of the IUPAC Subcommittee on Infrared and Raman Spectroscopy.*

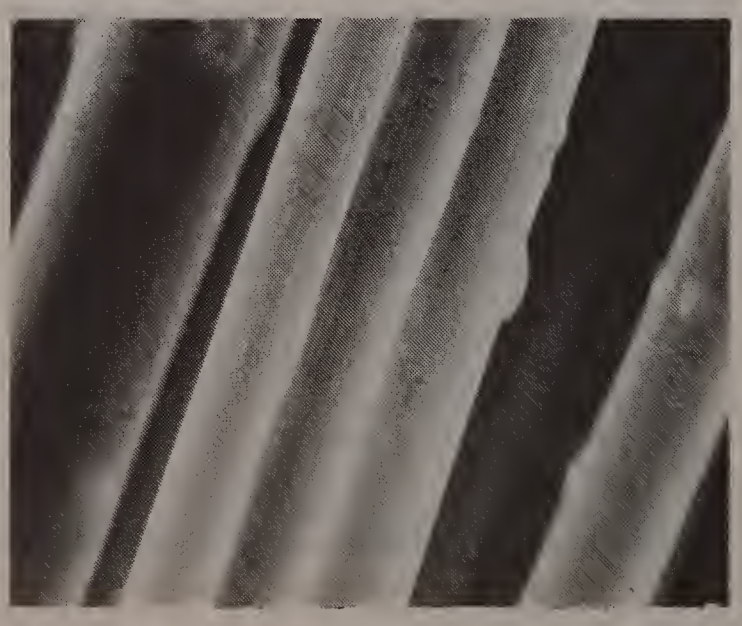
A new technique is reported, promising stronger, stiffer synthetic materials

In the last two decades, the strength of plastic parts has been dramatically improved by fibre reinforcing. Glass fibres, for example, exhibit high tensile strength and are now used extensively in plastic structural parts. Mechanical forces are borne by the fibres, which are held rigid by the polymer matrix. The composite material presents characteristics that cannot be achieved with either fibres or plastic alone. Glass reinforced plastic (GRP) provides greater strength per unit weight than metal, is relatively simple to fabricate in a wide variety of shapes and sizes, and is chemically inert to many corrosive substances.

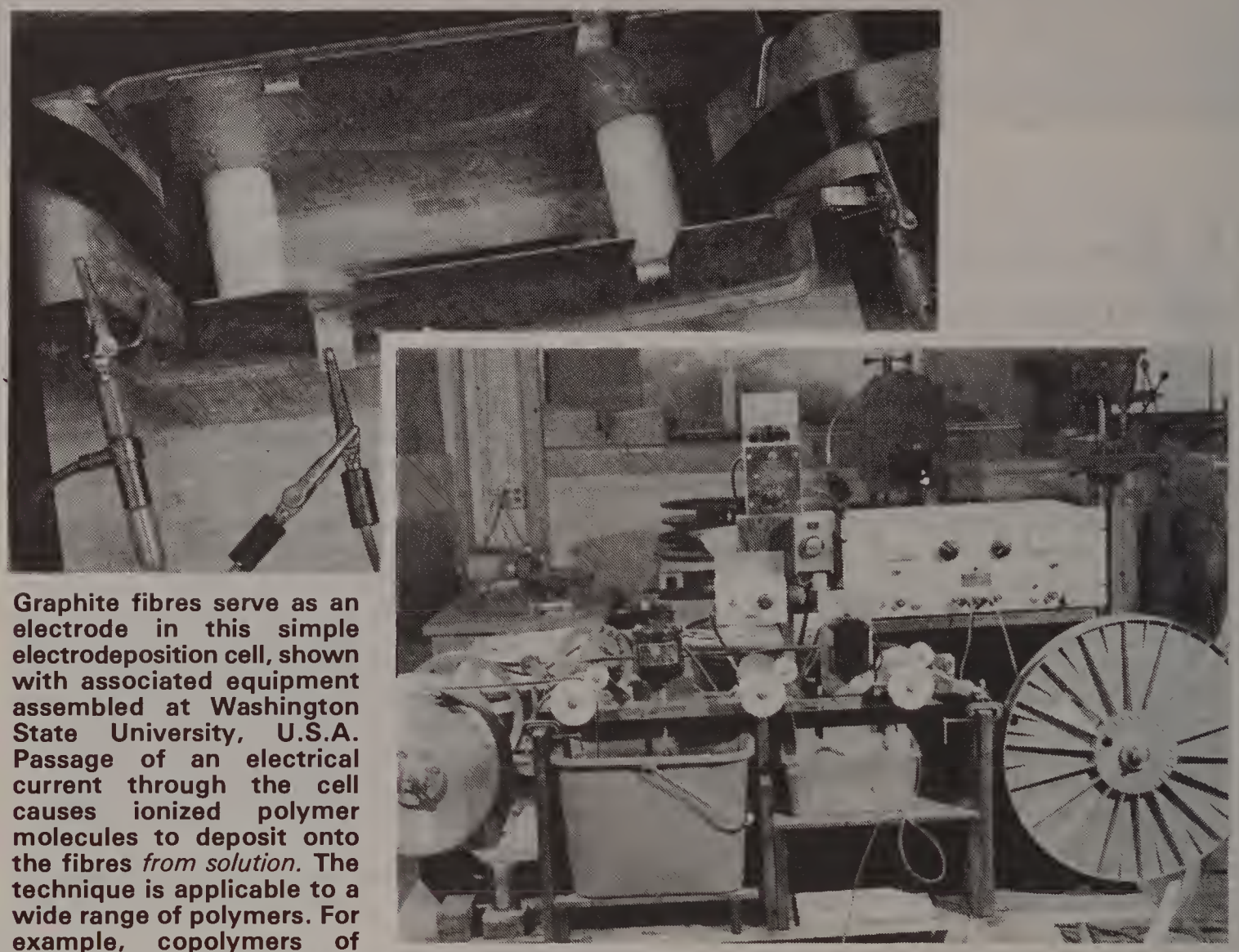
Several new types of fibre-reinforced plastics have been introduced in recent years. These could greatly extend the range of mechanical properties and applications which could be met by plastic composites, but technical problems have prevented the attainment of high strength and low cost which should ultimately be possible.

One of the most promising new composite materials is graphite fibre reinforced plastic. Although not generally as strong as plastics reinforced with glass or alumina, graphite composites offer very high stiffness in low-weight parts. They present about four times the resistance to bending as GRP parts of the same weight. Because graphite fibres are electrically conductive, electrostatic spray techniques can be used to paint moulded plastic parts (such as automobile body panels) to the same finish as surrounding metal pieces. However, the attainment of the ultimate strength, stiffness and impact resistance of graphite fibre composites has





Uncoated graphite fibres, such as the ones shown left, at 1400X magnification, impart stiffness to plastic composites but reduce impact and shear strength. Coating the graphite fibres enhances its bonding to the surrounding plastic matrix and improves the strength of the composite material. An especially promising coating technique is electropolymerization. It forms polymer coatings which are *chemically bound* to the surface of the graphite fibres. Below left is shown a fibre coated with polyacrylonitrile, while at right, a coating of poly(methyl methacrylate) remains on the fibers even after extraction with solvent for 120 hours *(scanning electron micrographs courtesy of Prof. R. V. Subramanian).*



Graphite fibres serve as an electrode in this simple electrodeposition cell, shown with associated equipment assembled at Washington State University, U.S.A. Passage of an electrical current through the cell causes ionized polymer molecules to deposit onto the fibres *from solution.* The technique is applicable to a wide range of polymers. For example, copolymers of maleic anhydride and styrene acquire a negative charge when free carboxylate groups are generated by partial hydrolysis. The ionized polymer may then be electrodeposited onto the graphite fibre anode. Electrodeposition differs from electropolymerization (in which the polymer is formed by polymerization *at the electrode* of an electrochemical cell), but both treatment methods improve the shear and impact strength of epoxy composites *(photos courtesy of Prof. R. V. Subramanian).*

been blocked by the lack of positive bonding between graphite fibres and the epoxy polymer matrix. In attempting to overcome this problem, several surface treatments have been developed to improve adhesion of epoxy polymer to graphite fibres. Until now, all these treatment methods could improve the material's shear strength only with the sacrifice of impact resistance.

Indications of a major technical breakthrough emerged at the IUPAC-sponsored symposium on *New Frontiers in Polymer Chemistry and Polymer Applications,* held earlier this year in India. Prof. Clement Bamford, a world-renowned polymer chemist who attended the conference and acted as official IUPAC representative, found that significant progress had been made in improving adhesion of the plastic matrix to the fibres by coating the graphite with an intervening layer of polymer.

Prof. Bamford reported that one "particularly effective procedure is to employ *electrochemical polymerization* on graphite fibres used as an electrode. Layers of polymer of controlled thickness (coating the graphite) may be obtained in this way and true grafting of the polymer to the surface occurs in many instances." With this technique, polymerization of monomer molecules in the electrolyte solution is initiated by ions or free radicals formed *at the graphite electrode* by an electron transfer reaction. Prof. Bamford observed that "the process is fundamentally different from conventional electrocoating" (in which ionized polymers in solution are deposited on a graphite electrode). Electropolymerization—unlike conventional surface treatment of graphite fibres—can enhance both the shear strength *and* impact strength of epoxy composites.

The unique characteristics of graphite fibres coated with the new process were discussed at the conference by Prof. R. V. Subramanian, who led the research team at the Materials Science & Engineering Department of Washington State University (USA). Prof. Subramanian and coworkers attribute the improved qualities of their coated fibres to chemical bonding of the polymer coating to the graphite surface. This was not completely unexpected, as carbon fibres are known to have -COOH and -OH organic functional groups, although in trace amounts. These groups evidently participate in the polymerization reac-

tion occurring at the surface of the fibre. After polymerization, the polymer coating contains unreacted functional groups which can bond to the encapsulating epoxy matrix.

Chemical grafting of the polymer film to the fibre could often be confirmed by electron micrographs. A coating of the normally-soluble polymer poly(methyl methacrylate), for example, could still be seen on the fibre after it had been extracted by solvent for 120 hours.

Prof. Subramanian and coworker James Jakubowski point out in a recent research paper (Electropolymerization on Graphite Fibers, *Polymer Engineering & Science,* Vol.18, No.7, May 1978, p.590) that the production of free radicals during electrochemical oxidation or reduction has been known for over a hundred years, but only within the last two decades have electrochemically-formed radicals and ions been used to initiate polymerization. Initial electropolymerization experiments were carried out with metal surfaces, but the polymer coatings were often powdery or solvent-swollen. However, Prof. Subramanian's group found that graphite fibre is a very good substrate on which to form a polymer film. The conductive graphite fibre, serving as one electrode in an electropolymerization cell, is immersed in a solution of monomer, solvent and electrolyte. Within seconds of applying a voltage, a polymer coating forms on the graphite fibre.

A range of polymer coatings can be produced by electropolymerization reactions. As well as initiating polymerization of vinyl monomers, electrode reactions can open up nitrile and acetylene functional groups in benzonitrile, phenylacetylene or other such intermediates. In this way, polyimide coatings resistant to high temperature can be formed.

Temperature resistance is only one important consideration in applications in which the composite could be exposed to fire; another is the release of carbon fibres. Lightweight graphite fibres could be carried by air currents to nearby electrical equipment, in which the conductive fibres might cause short circuits or power failure. This potential problem has been attracting increasing attention since carbon fibre-reinforced composites are being used to an increasing extent in automobiles and aircraft.

Prof. Subramanian and coworker J. Jakubowski inform *Chemistry International* that, according to their most recent research, electrocoating of graphite fibres can reduce electrical hazards in the event of fire. They found (their results will be published later this year in the journal *Composites)* that some organophosphorus coatings, formed by electropolymerization or electrodeposition, promote the formation of a relatively nonconducting char during exposure to fire. The char covers and binds the fibres into clumps and thereby minimizes the release of conductive fibre fragments into the air.

How does paint inhibit corrosion? Recent findings disprove old notions

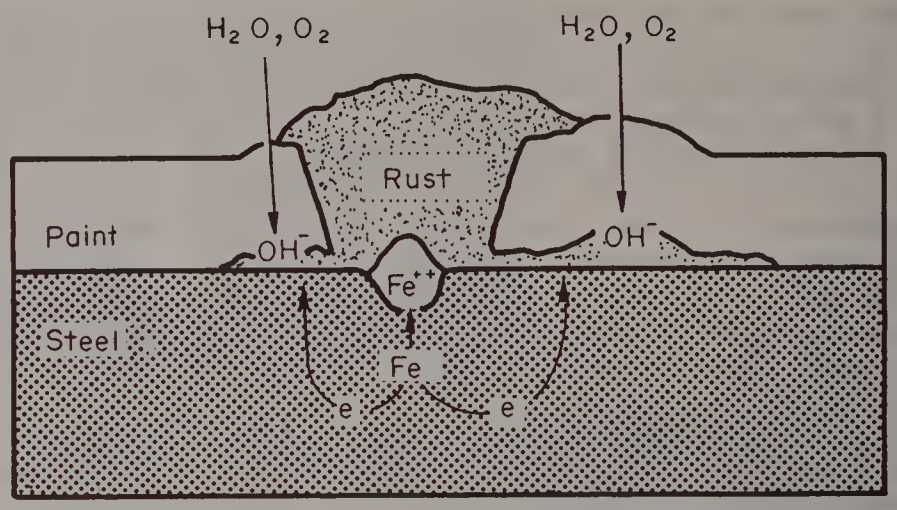
To combat corrosion of metal, paint is by far the most commonly used line of defense. Painting is generally the simplest and most effective means of protection, not only from corrosive chemical environments, but wherever metal is exposed to air. The protective barrier provided by a paint coating is not infallible, however, and even painted metal parts may become seriously corroded well before their useful life is ended by wear. Enormous economic benefits could be achieved if the lifetime of metal products (especially those made of steel) were extended by more effective corrosion protection.

Such advances could follow the greatly improved understanding of corrosion chemistry gleaned from recent experiments. These results show that some widely-held notions about how paint stops corrosion are very much in error.

Many chemists still accept the traditional explanation that paint halts corrosion by preventing oxygen and water from coming into contact with the metal suface. *Not true,* according to Ray A. Dickie and Arthur G. Smith, two researchers on the Engineering and Research Staff of Ford Motor Company (Michigan, USA). In a review article published in the January 1980 issue of *CHEMTECH,* they cite published results showing that oxygen permeates through a 0.1 mm paint film about as rapidly as it is consumed by freely corroding steel. So, paint does not prevent corrosion by blocking oxygen transport to the metal surface. Nor does it prevent water from reaching the metal suface. Diffusion of water through a paint film is sufficiently rapid to support a corrosion rate at least 10 times that of unpainted steel.

So how *does* paint prevent corrosion? Dr. Dickie and Mr. Smith explain that the rate-limiting step is the permeation of ions to the metal surface. The ability of a paint film to resist penetration of electrolytes determines how well—and how long—it will protect the metal surfaces. The greater the ion-exchange

Corrosion begins when electrolytes diffuse through the protective paint coating, or reach the underlying metal through a flaw in the paint surface. Once corrosion starts, hydroxide ions generated at the outside edge of the rust deposit attack the polymer paint film. As corrosion spreads laterally, the anodic site (where iron is oxidized) and cathodic site (where oxygen is reduced) become separated *(diagram adapted from "How paint arrests rust", CHEMTECH, January 1980).*



capacity of the paint film, the less is the corrosion protection. Eventually, electrolyte does penetrate to the metal surface and activate a corrosion cell. The initial corrosion products then cause chemical degradation of the polymer paint film. The coating loses it adhesion to the metal surface, and corrosion then proceeds at an accelerated pace. The onset of corrosion in this way often takes years, but may occur much earlier if the protective mechanism is circumvented by chipping or scratching of the paint surface. Once a corrosion cell is established, the paint coating acquires a new function: to slow the lateral spread of corrosion as much as possible.

When oxygen, water and salts contact a steel surface, the iron is dissolved by the oxidizing environment and forms ferrous ions. These are oxidized further to a mixture of hydrated iron oxides—termed "rust". However, the *oxidation* of iron is not the main factor contributing to the loss of adhesion of the adjacent paint film (and thus, the spread of corrosion). That is caused by the simultaneous *reduction* of oxygen and water:

$$O_2 + H_2O + 4e \longrightarrow 4OH^-$$
$$2H_2O + 2e \longrightarrow H_2 + 2OH^-$$

Both reactions generate hydroxide ions. The pH at the periphery of the corrosion site can rise as high as 12 or 13. This alkaline environment can cause degradation of the paint resin, for example by saponification of ester linkages of the polymer paint film.

While hydroxide attack has long been suspected as the cause of paint resin degradation, as Dr. Dickie points out to *Chemistry International,* only recently have surface analytical techniques allowed the site of adhesion loss and mechanism of hydroxide attack to be clearly defined. Recent work with these techniques have shown that resin degradation commonly results in cohesive failure *within* the coating film, rather than simple separation from the metal surface. Loss of adhesion or failure of the paint film exposes fresh surface to electrolyte, oxygen and water.

As rust builds up on the steel surface, the reduction of oxygen shifts to the periphery of the rust area. The oxide deposit limits oxygen diffusion to the underlying metal, but does not prevent corrosion from penetrating deeper. The underlying iron continues to oxidize. Electrons generated during oxidation are conducted through the metal to the outside edge of the rust deposit, where oxygen is reduced. Thus, the site of iron oxidation becomes physically separated from the site of oxygen reduction. Furthermore, while alkaline conditions are maintained by reduction at the outside edge of the rust area, oxidation and hydrolysis reactions cause acid conditions to develop beneath the rust deposit, accelerating further dissolution of iron.

$$Fe - 2e \longrightarrow Fe^{++}$$
$$Fe^{++} + H_2O \longrightarrow FeOH^+ + H^+$$

In resisting alkaline attack—and thus, impeding corrosion—some paints are better than others. As one might expect, the ability to contain corrosion depends upon the type of polymer comprising the paint matrix. However, pigments also perform an important role in slowing the spread of corrosion, and a wide variety of pigments have been observed to be effective in this way. Chromate pigments, for example, might function in a similar fashion as chromate solutions used to protect industrial heating and cooling systems. It is thought that chromate pigments ionize, and chromate ions diffuse to the metal surface. There, a corrosion-resistant metal-oxide film might be formed.

Paints containing high levels of zinc dust are also found to have improved corrosion resistance. Much of the protection afforded by zinc dust arises from the precipitation of zinc hydroxide, carbonate and oxide, which plug pores in the paint film and prevent further penetration by water and electrolytes.

Ray Dickie and Arthur Smith feel that corrosion should not simply be regarded as a problem for electrochemists, nor as a challenge solely for the organic chemist attempting to formulate better paints. They conclude that "The problems inherent in improving protective coatings demand the coordinated efforts of organic, inorganic and polymer chemists."

Chemists prepare "camera-ready" manuscripts to speed printing of research articles

It is no longer unusual for chemists to submit papers for publication as "camera-ready" manuscripts. It simplifies the publication process, greatly reduces its cost, and minimizes the time required for publication. A considerable number of journals now require that manuscripts be submitted in camera-ready form. The official IUPAC journal *Pure & Applied Chemistry,* for example, began publishing all articles from camera-ready manuscripts in 1977. Since then, many conference organizers have started to request that conference lecturers type their abstracts in camera-ready form so that they may be published in time to be distributed to conference participants.

The use of camera-ready manuscripts has been made possible by the revolutionary introduction of photo-offset printing. Unlike traditional methods which make up a printing plate from cast metal type, photo-offset printing utilizes a photochemical process to transfer the image of a page (including text, diagrams and photographs) onto a specially-coated printing plate.

"Camera-ready" copy is exactly that: the typed page prepared by the author is photographed on high-contrast film. The film is developed, and the negative image is focussed onto a light-sensitive printing plate. After chemical treatment, those areas of the plate surface that have been illuminated become hydrophobic and attract a film of ink.

Preparation of a manuscript in camera-ready form gives the author far greater control over how his article will appear in print. It eliminates costly typesetting (often, the most expensive part of publishing a manuscript) and the back-and-forth correspondence needed to correct galley proofs. There are no galley proofs. Furthermore, all compositing (page layout) is done by the author. By carefully checking his original manuscript, the author can ensure that photographs are printed rightside-up, paragraphs are in correct order, and the material is presented in a readable format. The original copy prepared by the author is reproduced exactly as it appears.

On the other hand, preparation of camera-ready copy imposes additional responsibility on the author. As well as ensuring that his material is technically accurate and readable, the author must be concerned with the appearance of the published article. When the author has completed his camera-ready original, "what he sees, is what he will get" in printed form. The printed article will ultimately be as legible, aesthetically pleasing and easy-to-read as the author determines through his care and interest.

Scientists have traditionally left the appearance and layout of their published articles to others (typesetters and compositors), and consequently, many do not give these much consideration. However, some thought and attention to the preparation of camera-ready copy can greatly enhance the readability of printed articles. An author must comply with the instructions of the journal editor to whom he submits a manuscript, and should take into account the procedures of the journal. Some (such as *Pure & Applied Chemistry)* reduce the size of the printed page during the photographic process to 75% that of the original laysheet. Others reduce the page to 90% the original size, or not at all. This is especially important for authors to bear in mind when labelling their diagrams: the lettering must be large enough to be readable after reduction in size.

Size is not the only difference between the appearance of the camera-ready laysheet that is photographed, and the same printed page. When viewing the original, the eye detects varying shades of light and darkness. Not so for the camera and printing process. Each point on the film is exposed only if the light level is above a certain threshold intensity. Thus, the camera is "blind" to the light blue graduation marks generally used to indicate borderlines and positioning of the title on the laysheet. A white correcting strip placed on the white laysheet may look sloppy to the eye, but photographic reproduction will not distinquish the slightly different tint of the white background. In this way, photographic reproduction is more forgiving than a human viewer.

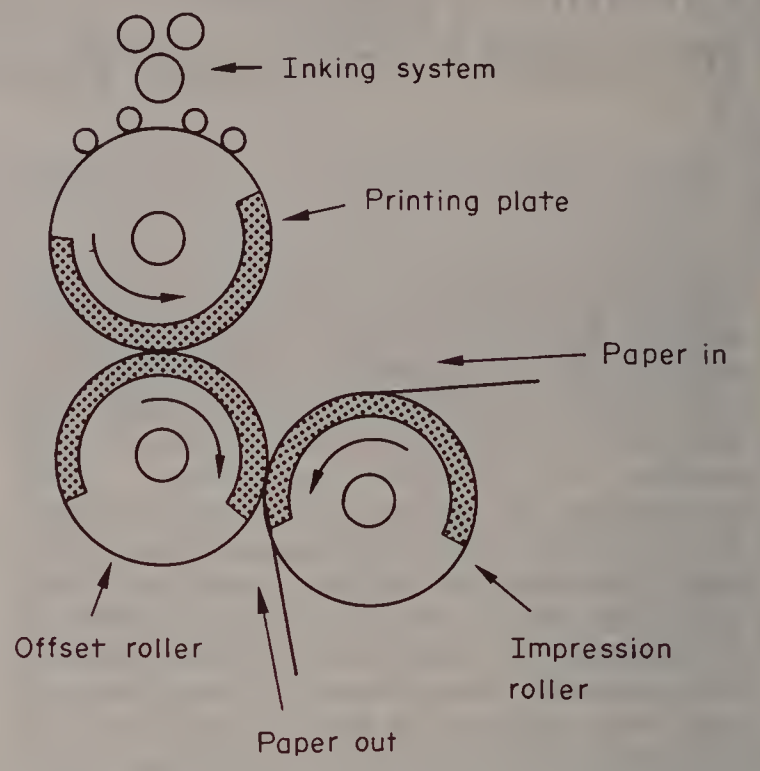
Other visual features—dark smudges, incomplete erasures, hand-drawn symbols—will look as bad or worse on the printed page. Furthermore, the reproduction process is colour-blind. The laysheet is photographed with black-and-white film (and printed with black ink). Areas where an author might attempt to use colour (say, to distinquish between different solutions) will generally appear black. Instead of colour, authors can make effective use of cross-hatching or dots. A good indication of how the printed page will appear is provided by photocopying the camera-ready laysheet on a reducing photocopying machine.

Although the requirements of individual journals may vary, the same principles apply in preparing good camera-ready material for any publication. A set of guidelines for preparing

AT LAST! THE MOMENT YOUR ARTICLE IS PRINTED

Photo-offset printing utilizes photo-chemical processes to transfer the image of the camera-ready laysheet onto the surface of a metal (lithographic) printing plate. The plate is folded around the printing cylinder and securely mounted. As the cylinder rotates, it is alternately washed with a hydrocarbon-based ink and with water. Ink adheres to hydrophobic areas comprising the image to be printed.

The printing plate does not transfer the ink directly onto the paper, as considerable pressure would be required to ensure complete contact. Such pressure would rapidly wear the lithographic plate, as the hydrophobic - hydrophilic image is only a surface feature of the plate. Rather, the ink is first transferred to a rubber offset roller, and then is transferred again as the paper passes between the offset and impression rollers.



camera-ready copy has recently been prepared by the International Federation of Scientific Editor's Associations (IFSEA), in association with the European Life Science Editor's Association and the Ciba Foundation. Their 48-page booklet was designed as a model to be used or adapted by editors to suit the requirements of their individual journals, but it provides information that would be helpful to any researcher who may, from time to time, submit material in camera-ready form.

The booklet is the product of a workshop held in May 1979 to recommend procedures for preparing camera-ready material for journal articles, monographs, conference proceedings, research reports and newsletters. Among its recommendations:

(1) Use an electric typewriter with a good black (not blue) plastic carbon ribbon. Clean the type element before starting.

(2) Use no more than 100 characters (letters, numbers and spaces) in the title.

(3) Always erase an error before retyping over it. Correct minor errors with a thin adhesive correcting tape, or apply white opaque correcting fluid (allow to dry thoroughly before typing over it). For larger corrections, retype the line or paragraph on a separate laysheet, cut out the substitute text, and insert into the text with paste. Use paste sparingly and align the new piece carefully. Leave no smudges or erasure marks.

(4) During the typing of the manuscript, leave space for photographs and line drawings. They should be located as near as possible to their mention in the text. Authors should inform the typist of the size of illustrations so that appropriate space can be left in the text. Leave a blank margin of 1 cm above and below the illustration (leave out one margin if the illustration appears at the top or bottom of a page).

(5) Diagrams (line drawings) should be mounted in the space allocated for them on the laysheet.

(6) Half-tones (photographs with gray areas) should be sharp, glossy prints with good contrast. They cannot be photographed directly with high-contrast film, and should not be mounted on the laysheet. The publisher will undertake a special process that reproduces the photograph as a fine dot pattern (the lightness or darkness at each point is determined by the size of the dots). Submit the photograph separately, but indicate its correct positioning by mounting a photocopy in its place on the laysheet.

(7) If you wish to reproduce someone elses previously-published material (tables, illustrations text of significant length), obtain permission of the copyright holder.

(8) When the manuscript is complete, place the laysheets between two sheets of cardboard or other protective covering before mailing. The author should keep a photocopy.

Copies of the booklet *Model Guidelines for the preparation of camera-ready typescripts by authors & typists (including bibliographic references in science publications)* can be obtained from the Editorial Department, Ciba Foundation, 41 Portland Place, London W1N 4BN, U.K. Enclose payment for £1.50 (including surface postage, or add £0.50 for airmail) and a self-addressed adhesive label.

A new concept alters the way chemists view "atomic weights"

For over a century, chemists have accepted that "the atomic weight of an element is a constant of nature". This basic postulate of general chemistry has, in fact, never been true. However, the fallacy mattered little until within the last two decades, when sophisticated techniques greatly increased the accuracy of atomic weight measurements. For the first time, experimental uncertainty of atomic weight measurements was considerably less than the actual variation of atomic weights from one sample to the next. The problem is compounded by the use of isotopically-modified tracer compounds, which alter significantly the isotopic composition of the material. Furthermore, exploration of our Solar System has revealed that atomic weights of extra-terrestrial material differs from elements on Earth.

As a consequence, increasing international attention has focussed on the inadequacy of the term "atomic weight" as it is presently defined. The International Commission on Atomic Weights (ICAW) has been concerned with clarifying the definition, and making the practicing scientist aware of the problem. In addition, the Interdivisional Committee on Nomenclature and Symbols (IDCNS) of IUPAC has been urging that the *name* "atomic weight" be discarded, since what is meant by the term 'atomic weight' is not a weight. Other non-chemical scientific bodies (the International Organization for Standardization and the International Union for Pure & Applied Physics) advocate the term "relative atomic mass".

How did this confusing situation originate? The basic concept of atomic weights is attributed to Dalton, who noted that elements combine in simple numerical ratios of their atoms. He assembled the first table of relative atomic weights of the elements. By the early 1900's scientists had agreed to base the atomic weight scale relative to oxygen. Then, the invention of the mass spectrometer led to the discovery in 1929 that "pure" oxygen is actually a mixture of several isotopes, each with a different mass. This led to the first split between how chemists and physicists viewed atomic weights. Physicists chose to base their atomic weight scale on the isotope $^{16}0$, while chemists defined a scale using an atomic weight value of 16 for *elemental* oxygen (the normal isotopic mixture found "in nature"). By 1961, chemists and physicists had agreed to prepare a new atomic weight scale defined relative to carbon-12. However, the different terminology used by chemists and physicists remained.

An even larger problem was soon to emerge. It was soon found that the "natural" isotopic composition of boron and oxygen varied, depending upon the origin of the sample. Even more extreme variations were found for elemental hydrogen, whose content of deuterium isotope could be as high as 230 parts-per-million (for crystalline water in Precambrian rock from Russia), or as low as 44 ppm for electrolytic hydrogen. This meant that the atomic weight of hydrogen could be 1.00787 *or* 1.008606, depending upon which sample one chose to represent the "natural" composition of hydrogen.

Elemental sulfur also exhibits significant variations in the relative amounts of its

Take this quiz to check your knowledge of atomic weights

(1) Consider Element X, whose stable nuclide X-100 is 20% converted to X-104 by irradiation in a nuclear reactor. The radio- isotope decays to the normal nuclide with a half- life of 48 hours. On Monday morning, you are given a sample of Element X, taken directly from a nuclear reactor. What is the atomic weight of Element X in the sample?
(A) 100.8 on Monday
(B) 100.4 on Wednesday
(C) 100.2 on Friday
(D) All of the above.

(2) An atomic weight is:
(A) Not a weight
(B) a 'relative atomic mass', but this might be misinterpreted by physicists
(C) an 'average relative atomic mass of an element', but this might not be understood by anyone
(D) Subject to change without notice
(E) All of the above.

isotopes, ^{34}S and ^{32}S. Barite in the Sea of Japan, for example, contains 4.6% ^{34}S, giving a calculated atomic weight of 32.060. The isotopic composition of Texas marcasite, on the other hand, corresponds to an atomic weight of 32.072. The mineral troilite in various meteorites and in deeply-buried terrestial sulfur has an effective atomic weight of 32.064.

To overcome obvious shortcomings in the present concept of atomic weight, the International Commission on Atomic Weights has proposed that the atomic weight of an element be defined for material *of a specified source.* No longer would one speak of *the* atomic weight of sulfur, but rather, the atomic weight of sulfur in a particular sample. Tables of standard atomic weights will, however, continue to be published by ICAW (based on measurements of each element as it is found in natural terrestial sources). It would be understood that these atomic weights might differ slightly from atomic weights in a given sample.

What about the different terms used by chemists and physicists to mean "atomic weight". Clearly, it would be advantageous to standardize terminology, and "atomic weight" is obviously not the best term to use (it is not a weight, and in fact, is a dimensionless quantity). But arguments can also be presented for retaining the term "atomic weight". These are pointed out by Dr. Norman Holden, Chairman of the IUPAC Commission on Atomic Weights and Isotopic Abundances. In a letter presenting his personal view to *Chemistry International* (upon which this article is based), he states that "atomic weight" is "a well-established term with a definite meaning which has been used by chemists for a very long time without giving rise to any confusion." While it is true that an atomic weight is not a weight (but a relative atomic mass), Dr. Holden feels that no great difficulty arises from use of the term "atomic weight". After all, he notes "a dipole moment is not a moment, resolving power is not a power, and electromotive force is not a force."

If the term "atomic weight" is to be changed, what would it be changed to? The term "relative atomic mass" might create further confusion, as physicists use this term to mean the mass of *a single atom* of an individual isotope. No replacement term has yet been proposed which is completely accurate, unambiguous and simple. The concept would be described accurately by the term "average relative atomic mass of an element", but this would likely be too cumbersome to gain wide acceptance.

The controversy about what to call "atomic weights" might well continue for some time, especially in view of the highly variable nature of atomic weights. They change with time (with natural radio-active decay), and from sample to sample. To an increasing extent, atomic weights are proving to be one of the least constant quantities of nature.

COURSES

ENVIRONMENTAL SCIENCE & TECHNOLOGY

The eleven-month International Course in Environmental Science & Technology is aimed at chemists, biologists and chemical and agricultural engineers who require specialized knowledge relating to the environment. The course is organized annually, and will next be held 23 October 1980 -12 September 1981. It consists of lectures, laboratory work, workshops, projects and field studies encompassing a wide variety of subjects. An interdisciplinary and quantitative approach will be applied to environmental problems, including material on statistics, computer programming and simulation modelling. Special attention will also be paid to relevant aspects of economics and environmental law.

Candidates should have a good command of English, the language of the course. The tuition fee is 2 000 Dutch Guilders, and an additional 700 Dfl for field trips abroad to institutes, laboratories and industrial plants (such as treatment works, waste disposal plants, pollution control authorities and environmental research laboratories).

Applicants must hold a degree in chemistry, biology, chemical engineering or related branch of study. Furthermore, participants are expected to have at least three years of relevant practical experience. Candidates may be sponsored by their national government, university or employer; or may avail themselves of fellowship facilities of various United Nations organizations.

The course is organized by the International Institute for Hydraulic and Environmental Engineering (IHE), in cooperation with Delft University of Technology and Netherlands Universities Foundation for International Cooperation (NUFFIC). Additional information about the course, admission and financial assistance are available from The Registrar IHE, NUFFIC, P.O. Box 90734, 2509 LS The Hague, The Netherlands.

RECOMBINANT DNA TECHNIQUES

A practical course on recombinant DNA technology, sponsored by COGENE, will be held from 2 - 22 February, 1981 at Benares Hindu University, Varanasi, India. COGENE is the Committee on Genetic Experimentation of the International Council of Scientific Unions and the course is being organised with the cooperation of Unesco.

Laboratory exercises will be complemented by lectures and discussions. The principal instructors for the course will be Dr. A. I. Bukhari, Dr. J. Sambrook (Cold Spring Harbor Laboratory, N.Y., U.S.A.) and Dr. A. M. Skalka (Roche Institute, Nutley, N.J., U.S.A.). Students, who should hold either a bachelor's degree or a doctorate, must live or work in the Indian subcontinent or a South-East Asian country. The course will be taught in English and proficiency in that language is essential. Funds are available to help defray the costs of student travel and subsistence.

Further information and application forms may be obtained from: Dr. M. Chakrovorty, Department of Biochemistry, Institute of Medical Sciences, Benares Hindu University, Varanasi-221005, U.P. India.

Chemicals & Cancer, Part I
The origin of cancer

Cancer strikes almost a million and kills over 400 000 people in North America alone each year; one person in four will have some form of cancer during their lifetime. As the danger from the infectious diseases (e.g. tuberculosis, small pox, pneumonia) has diminished during this century, the incidence of death from heart disease or cancer has become predominant in the Western World. Although cancer mortality is second to heart disease, the latter is levelling off, whereas cancer is steadily increasing. Help is needed from many sources to conquer this giant, and chemistry is playing an indispensable role in the fight against cancer.

The recognition of chemical carcinogens in the environment, and the search for new and better cancer chemotherapeutic drugs are both active, growing areas of research. This article explores the reasons why some chemicals are carcinogenic, whereas others are effective anticancer agents. Although many questions remain unanswered, there are some glimmers of understanding of mechanisms of carcinogenesis and drug action.

by Prof. Keith Vaughan
Saint Mary's University
Canada

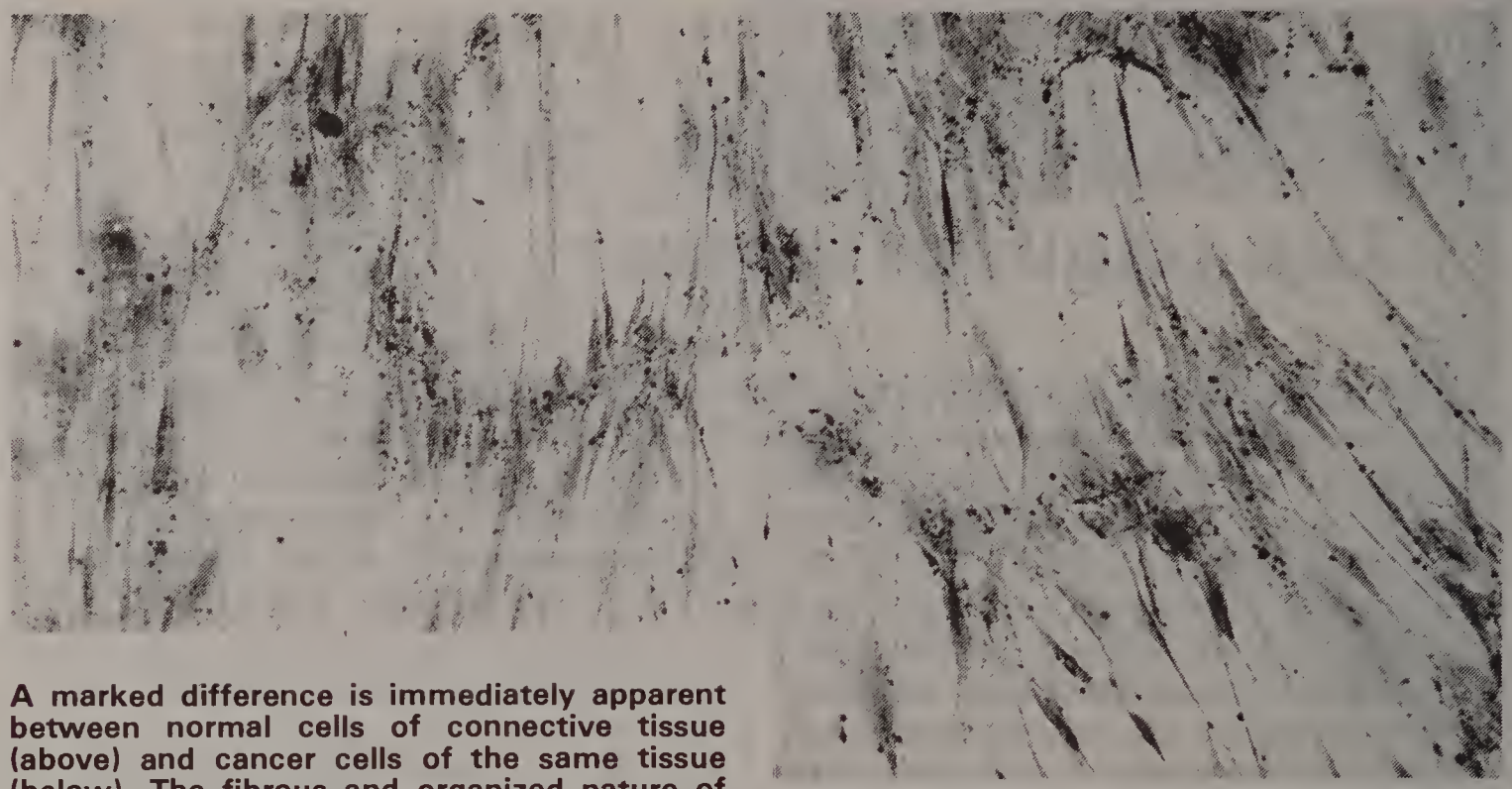
Cancer is a group of many diseases (about 200 known types) affecting various parts of the body in different ways, but the primary disorder is always the same—disorganization and uncontrolled growth of the affected tissues. This growth eventually leads to the formation of a *tumour* (usually detected as a lump), which can often, but not always, be removed by surgery. Cancer can spread throughout the body by detachment of small clumps of tumour cells from the primary tumour, transport to distant organs through blood or lymph vessels and proliferation at secondary sites—the process of "metastasis". Indeed, the majority of cancer deaths are not caused by the primary tumour, but rather by secondary tumour growth elsewhere in the body. The tendency of malignant tumour cells to spread ("metastasize") is the most lethal aspect of cancer, and the main thrust of chemotherapy is to destroy these metastases, or secondary growths.

The origin of the cancer cell has occupied scientific thought for many years. The exact sequence of events leading to the formation of a detectable tumour is difficult to assess, but much has been learnt about the "phases" of cancer development. There are at least three recognizable phases of cancer—initiation, promotion, and growth. In the initiation stage, which is a complicated process in itself, a presumably "normal" cell interacts with a carcinogenic agent to become "pre-cancerous". This pre-cancerous cell can be extremely stable, and its lifetime may extend for the lifetime of the human or animal. Indeed, it has been shown in experimental animals that exposure of a foetus to carcinogens in the womb can lead to cancer after birth; thus, *in utero* exposure to carcinogens may be a real danger amongst women who smoke during pregnancy.

It is also clear that simple exposure to the carcinogen does not always lead to cancer and that a tumour "promoter" is required to convert the pre-cancerous cell to the truly malignant cancer cell. It is believed that the phases of initiation are reversible up to a point, but that reversibility is lost once a neoplastic stage is reached. Nevertheless, the possibility of treating cancer by "reverse transformation" is a real one, and will be discussed more fully later.

The existence of tumour promoters was clearly demonstrated more than 30 years ago. Phorbol esters, which occur in some plant oils (specifically oil of *croton,* a brownish-yellow oil from seed of croton, a tropical plant with medicinal counter-irritant properties), enhance the incidence of tumours in mice pretreated with carcinogens. Recent research suggests that saccharin may be a promoter, rather than an initiator, of carcinogenesis.

The carcinogenic agent, the "initiator", may be in the form of radiation (radioactive fallout, X-rays, cosmic rays), it may be a virus (e.g. leukemia in animals can be virus-induced) or more commonly, it may be chemical, e.g. nitrosamines (in tobacco, smoked meats), polycyclic hydrocarbons (in automobile exhaust), carbon tetrachloride (dry cleaning solvent), benzene (laboratory solvent), and many others. There is insufficient space in this article to detail every known chemical carcinogen, and it is not yet possible to predict chemical carcinogenicity with



A marked difference is immediately apparent between normal cells of connective tissue (above) and cancer cells of the same tissue (below). The fibrous and organized nature of normal cells is evident, while cancer cells have greatly enlarged nuclei, very different shape and function, and show obvious disorder *(photograph courtesy of Dr. T. Ghose, Department of Pathology, Dalhousie University, Canada).*

any certainty. However, the mechanism of carcinogenesis is quite well understood in some cases.

For example, polycyclic aromatic hydrocarbons are activated metabolically by an enzyme, aryl hydrocarbon hydroxylase (AHH). AHH is an oxygenase enzyme bound to cell membranes. It acts upon polycyclic hydrocarbons, many drugs, insecticides, and also normal body metabolites, oxidizing them to phenolic and other derivatives. There is evidence that the enzyme converts the carcinogen to an epoxide intermediate, which is highly reactive. This may combine covalently with cell constituents, thereby possibly triggering the carcinogenic process.

Several studies have shown that the level of AHH can rise dramatically when polycyclics and other carcinogens are administered to animals. A reliable test of AHH inducibility could someday be used to identify cancer-susceptible individuals.

The metabolism of nitrosamines is also reasonably well understood. Nitrosamines usually require metabolic activation to show mutagenesis. The pathway of metabolism involves hydroxylation by enzyme to give an unstable hydroxymethylnitrosamine, which immediately decomposes to methyl diazotate. This very reactive alkylating species could interact with cellular DNA, thereby causing a mutation in the genetic make-up of the cell.

The common feature of all carcinogenesis is believed to be a genetic mutation, which leads to cells with the control mechanism not functioning. In fact,

neoplastic transformation can be induced by a direct perturbation of DNA—such transformation of syrian hamster embryo cells occurs when the cells are treated in culture with 5-bromo deoxyuridine and exposed to near ultra violet light. The genetic characteristics of these transformations leads to the hypothesis that cancer may also be hereditary; a genetic defect may give rise to pre-cancerous cells without the necessity for initiation by a carcinogen. Exposure to a tumour promoter would then lead to cancer. Indeed, in a number of recessively inherited human disorders, affected individuals are cancer-prone. The prevalence of cancer among such individuals can be orders of magnitude higher than in the general population. A child with a primary immune deficiency disease has a hundredfold chance of getting cancer over that in a population of normal children. Some form of biological engineering (e.g. recombinant DNA) may eventually provide a means of correcting the fundamental fault in the immune system. However, concrete evidence on how the basic defect of an immune deficiency syndrome is linked to the induction of cancer is still lacking.

Some of these "hereditary" disorders are associated with defects in the ability of cells to *repair* certain kinds of physical or chemical damage to their DNA. The existence of such disorders is direct evidence that damage to DNA can be carcinogenic. It provides the best available evidence for a causal association between mutagenic and carcinogenic agents—an association used extensively as an environmental detection screen for carcinogens. It is often possible to show that there is an association between exposure to specific environmental factors—chemicals, sunlight, tobacco smoke, radiation—and the onset of cancer. As long ago as 1775, the association between the exposure of chimney sweeps to soot and their increased incidence of cancer of the scrotum was noticed. Asbestos, arsenic, and benzene are more recent examples of chemicals that have been classified as human carcinogens from statistical studies of the incidence of disease.

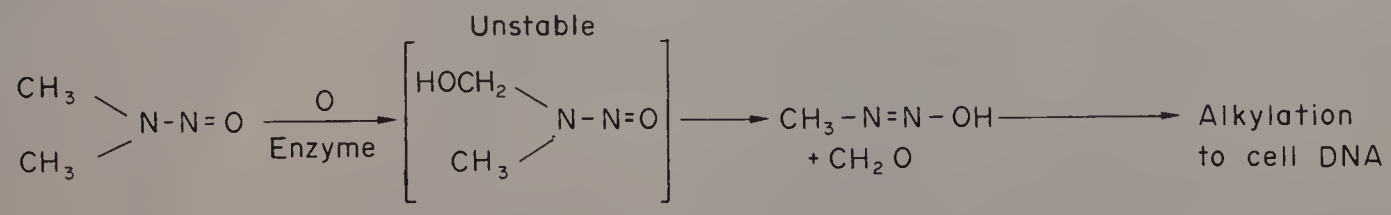
Epidemiology is of limited value for regulation of toxic substances because of the nature of chemical carcinogenesis. The crucial fact is that for most chemical carcinogens, there is a latent period of 20 years or more between the first exposure to the chemical and the onset of cancer. It is difficult to develop evidence of carcinogenicity from epidemiology alone because of difficulties of tracking people exposed to a particular agent and multiple exposure to more than one agent at a time. Effective regulation of toxic substances requires identification of carcinogens before there is significant human exposure; conventional methods use long term bioassays in animals, usually rodents with a short life span. Approximately 500 animals are required for one potential carcinogen (according to guidelines of the US National Cancer Institute).

Chemicals which are carcinogenic in humans are also carcinogenic in animals—but not always vice-versa. Despite reservations about the validity of such tests, a chemical which is carcinogenic in appropriate laboratory animal tests systems must be treated as if it were carcinogenic in man. Although animal results are the best tool available to identify such risks, the problem is in obtaining them. There are simply not enough trained personnel and laboratory facilities to test all new chemicals by animal bioassays. There has thus been a great deal of interest in the development of short term, relatively inexpensive assays that could be used to identify those chemicals that are potentially most hazardous. However, there is considerable controversy about these short-term tests.

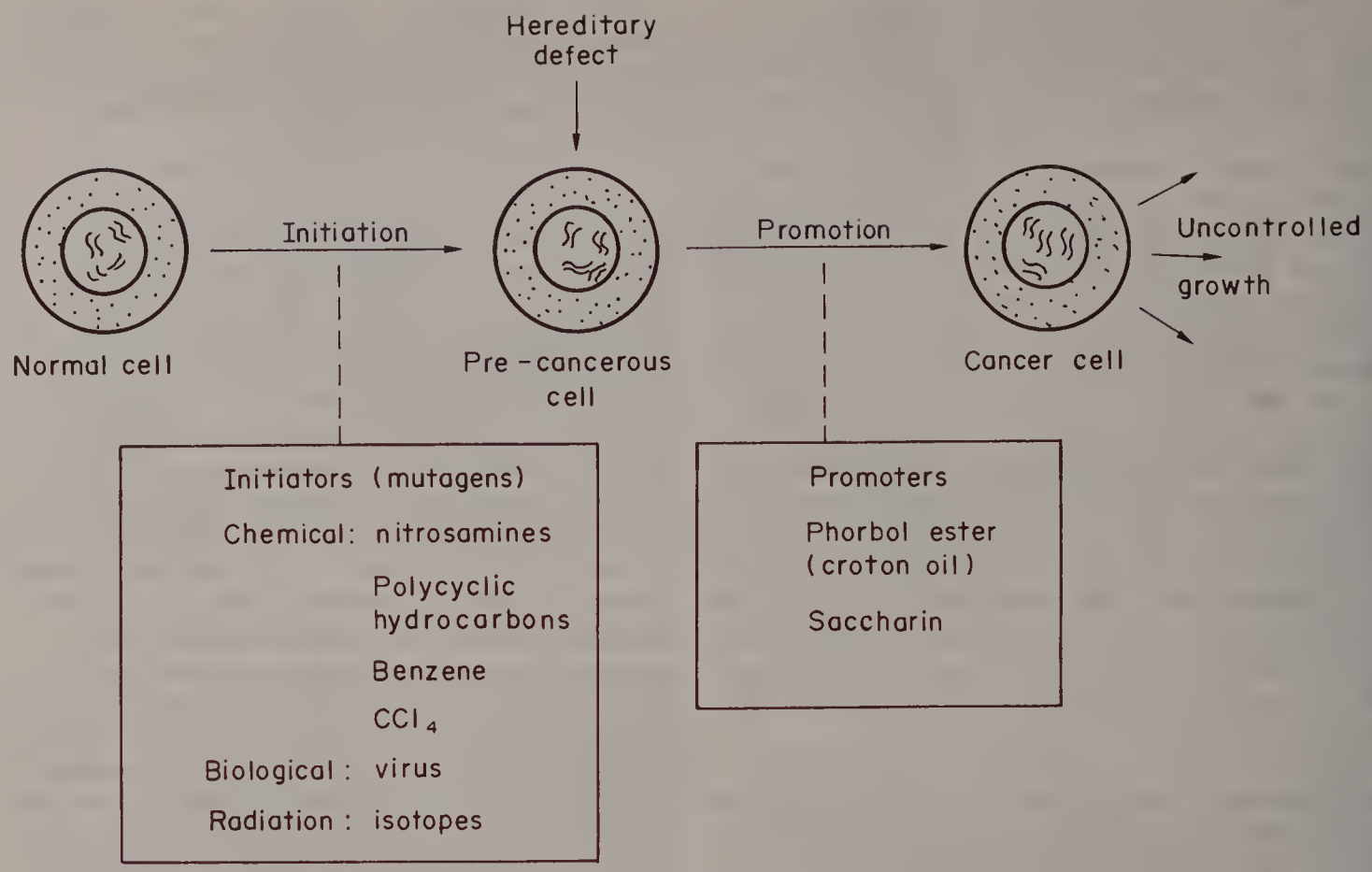
One of the first short-term test—certainly the most thoroughly studied—was developed by Bruce Ames of the University of California at Berkeley. He used mutant strains of the bacterium *Salmonella typhimurium* that are unable to synthesize the essential amino acid histidine. Exposure of the mutant strains to mutagens (chemicals that alter genetic information by interaction with DNA) corrects this defect and allows the bacteria to grow in a histidine-free medium. Since interaction with DNA is believed to be the first important step in carcinogenesis, Ames says, most mutagens are potential carcinogens. The test shows a strong correlation between carcinogenicity and mutagenicity. Ninety percent of those chemical carcinogens tested give a positive result in the Ames assay.

The Ames test costs between US$300 and US$1000 per chemical tested, and is used in over 1000 laboratories around the world. A number of companies use it routinely for premarket testing of new compounds; the Ames test provided the first suggestion that hair dyes and Tris, the flame retardant used on children's pyjamas, are potential hazards. Sometimes the Ames test can provide evidence about the mechanisms of metabolic activation of carcinogens, many of which are not carcinogenic in the form in which they are inhaled or ingested. Many non-mutagenic compounds become mutagenic only when metabolized by enzymes contained in a homogenate of liver cells. Cells from a variety of species can be used to demonstrate species sensitivity.

The success of the Ames test has stimulated a great deal of interest in short-term tests, and there are now at least 80 different tests in various stages of study.



Some compounds, such as nitrosamines, become mutagenic when activitated by metabolic processes. Once in the body, nitrosamines are hydroxylated by cell enzymes. The unstable product decomposes to methyl diazotate, a reactive alkylating agent. This compound could react with DNA of the cell nucleus, induce a mutation, and initiate the cell to a pre-cancerous state.



A cancerous tumour develops in several stages. Exposure of a normal cell to a carcinogenic chemical, virus or radiation might initiate the cell to a pre-cancerous condition—or, the cell may have always been pre-cancerous because of a hereditary defect. This cell may be extremely stable and might never become cancerous. In fact, the initiation process might even be reversible. However, certain compounds might promote the cell to a cancerous condition.

Briefly, these tests fall into four broad categories: (a) tests with microorganisms, like the Ames assay; (b) tests with intact organisms, such as a test for damage to a specific, sex-linked recessive gene in the fruit fly *Drosophila.* The advantage of these tests is that the organism retains the enzymes necessary for metabolic activation; (c) tests that look for genetic damage and mutations in cultured mammalian cells, such as a test which looks for unscheduled DNA synthesis. These tests seem to be very sensitive; (d) tests for in vitro transformation, such as the transformation of hamster embryo cells mentioned earlier. These tests focus on the changes in structure and growth characteristics that accompany transformation of healthy mammalian cells into malignant ones.

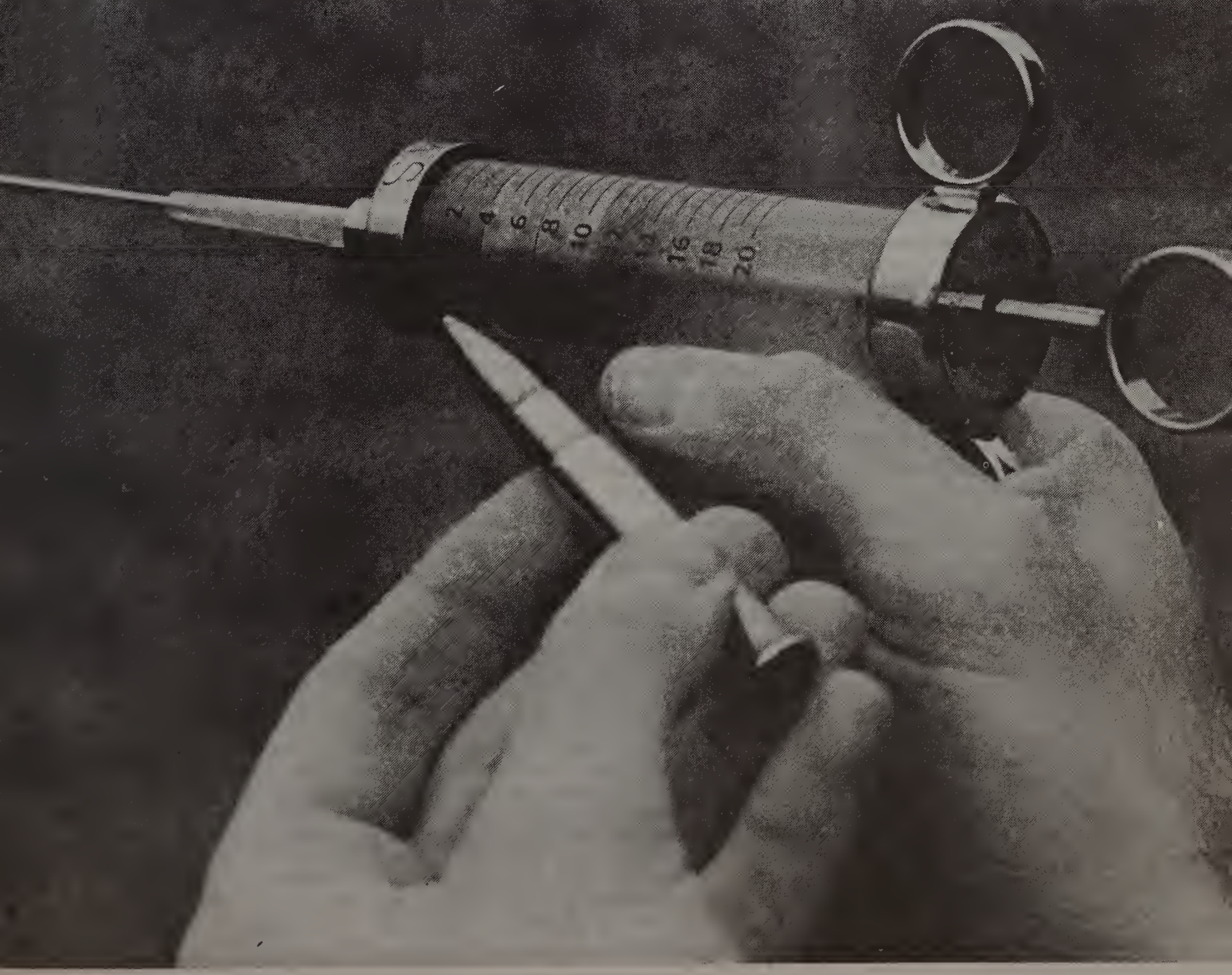
Future studies will probably employ a battery of these tests so that chemicals that escape detection in one system can be identified in another. It seems clear that the use of short-term assays will continue to accelerate, and that they will be woven into the fabric of governmental regulation rather quickly.

Chemistry has a role to play in both the prevention and cure of cancer. Identification of chemicals that initiate and promote carcinogenesis is the first step towards the eventual elimination of such species from the environment and the prevention of many cases of cancer. However, one cannot help but be pessimistic about the success of the environmental approach. As long ago as 1950, epidemiologic evidence established the causative association between cigarette smoking and lung cancer. Thirty years later, tobacco usage still accounts for more than one-third of all male cancer deaths in North America and Britain. Until public awareness becomes more general, the search for new drugs for the treatment and cure of cancer will go on.

Chemistry & Cancer, Part II
Search for the magic bullet

Selectivity is the essence of chemotherapy. Conventional chemotherapeutic agents are designed to selectively kill cancer cells without affecting normal cells. In practice, this goal turns out to be very difficult to achieve because of the very close similarity between normal and cancerous cells. After all, the cancer cell started out as a normal cell and retains a large part of the genetic makeup of the original cell. The differences between normal and cancer cells, when they are found, are subtle and not easy to exploit.

There is a great need for research into fundamental biochemistry and structure of the cancer cell in order to find real exploitable differences. Without this information, the cancer chemotherapist is faced with a near-impossible task—to find the "magic bullet".



by Prof. Keith Vaughan
Saint Mary's University
Canada

Ironically, the first cancer drugs were developed from substances originally designed to be nerve gases. The nitrogen mustards were studied in the 1930's as potential agents for chemical warfare like the infamous "mustard gas" of World War I. Although they were never used in World War II, the nitrogen mustards were observed to have a peculiar side effect—bone marrow depression, the slowing down of the production of white blood cells. This is exactly the therapeutic property necessary for the treatment of leukemia, a form of cancer in which control of the production of white blood cells is lacking. Nitrogen mustards, and other cancer drugs generally classified as "alkylating agents", have been used clinically in treating some forms of human cancer, e.g. Hodgkin's disease, with some success. In 1947, leukemia victims had only 2 - 4 months life expectancy, whereas now, over half can expect at least a five-year survival.

Treatment of cancer involves four main lines of attack—surgery, radiation therapy, chemotherapy, and immunotherapy. Surgery (removal of the primary tumour) is the first line of attack. Radiation treatment and chemotherapy are administered to destroy secondary tumour growth from metastasis. Immunotherapy involves the stimulation of the patient's own immune system to generate anti-tumour antibodies. The latter type of therapy is still in its infancy, but may offer the greatest hope for a *selective* means of attacking tumour cells (see box).

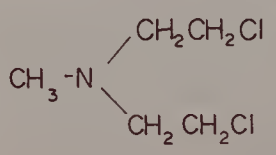
Most anti-cancer drugs exert their toxic effect on cancer cells by interference with the replicative process of the cell, i.e. the biosynthesis and replication of nucleic acids. This strategy derives from the somewhat mistaken assumption that the growth of a tumour is related to the rapid proliferation of cancer cells relative to normal cells. Not all cancer cells proliferate rapidly, and some normal cells, e.g. cells of the bone marrow, the gut lining, the lining of the urinary tract, and the gonads, replicate quickly.

The essential feature of cancer is that the growth is *uncontrolled;* normal tissues *may* be capable of growing quickly but only when required, as in the case of skin cells when the skin is cut. In spite of these drawbacks, most drugs in current use inhibit cell division by interfering in one way or another with the synthesis or use of nucleic acids, or during subsequent mitoses (division of the cell nucleus).

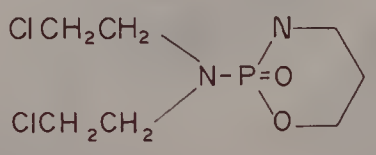
Recent studies have revealed that some cancer cells have peculiar requirements for the amino acid methionine. Normal cells grow equally well in tissue culture medium supplemented with methionine, or in methionine-depleted media containing homocysteine, Vitamin B12 and folic acid. On the other hand, certain tumour cells show stringent methionine requirements. These tumour cells simply do not grow in methionine-deficient media, but the reasons are unclear.

Antitumour agents can be placed into four classes: (1) alkylating agents, (2) antimetabolites, (3) antibiotics, and (4) miscellaneous.

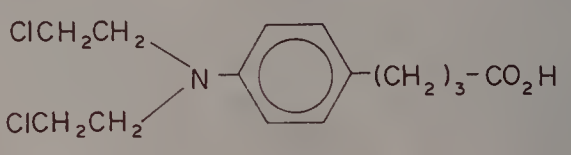
Most of the alkylating drugs are nitrogen mustards (i.e. $R\text{-}N(CH_2CH_2Cl)_2$), ethyleneimines or alkanesulfonates. They react with the nucleophilic hydroxyl, amino, carboxylate, mercapto or imidazole groups of proteins and nucleic acids, but the detailed mechanism of action is not clear. Bifunctional alkylating agents are certainly capable of forming cross-links between the strands of the DNA molecule, thereby preventing replication. However, the high degree of reactivity of these molecules leads to indiscriminate reactions with cellular nucleophiles. Some clinically useful drugs of this type are melphalan, cyclophosphamide, busulfan, chlorambucil, and nitrogen mustard. The nitrosoureas (e.g. CCNU, cyclohexylchloroethylnitrosourea) represent a relatively new class of promising anticancer agents with a broad spectrum of antitumour activity.



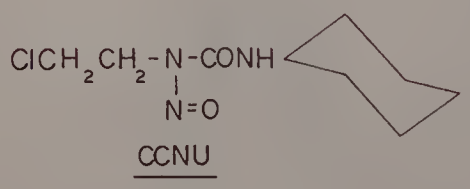
Nitrogen mustard



Cyclophosphamide



Chlorambucil



CCNU

Among the first anti-cancer drugs were the nitrogen mustards. The compounds were originally developed during the 1930's as chemical warfare agents. Their unusual side-effect, slowing white cell production, was later recognized as a useful property for treating leukemia. Other alkylating drugs, such as cyclophosphamide and chlorambucil, have the same basic mode of action. They interfere with the functioning of cancer cells by reacting with nucleophilic functional groups of nucleic acids, sometimes cross-linking strands of DNA. Especially promising for their broad spectrum of anti-tumour activity are the nitrosoureas, such as CCNU, a relatively new class of alkylating agents.

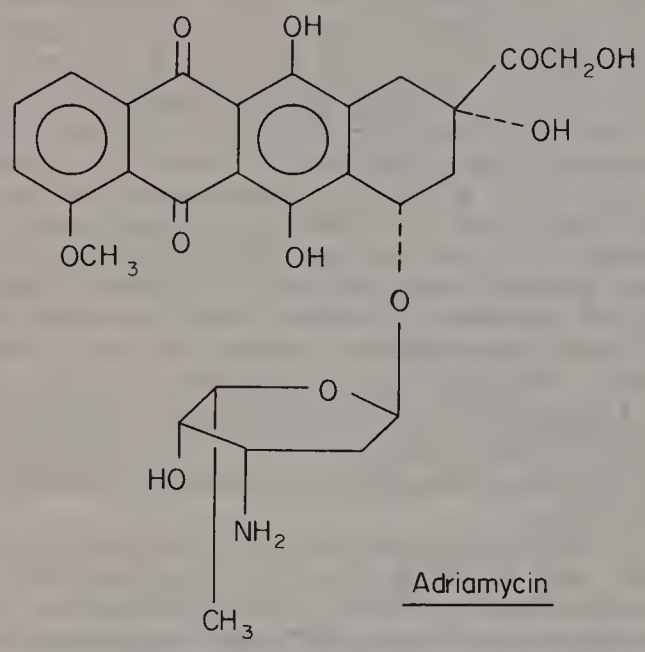
Antimetabolites, otherwise known as "look-alike" antagonists, are structurally related analogs mistakenly taken up by a cell, and when inside, interfere with the normal metabolism and proliferation of the cell. Various molecules are needed by the cell to form nucleic acids; antimetabolites must be sufficiently alike the natural metabolite to be incorporated into the biosynthetic pathway. Hence, many purines and nucleosides, the building blocks for nucleic acid biosynthesis, have antitumour activity. The best known examples are (the natural metabolite is in parentheses): methotrexate (folic acid), 6-mercaptopurine (adenine), 5-fluorouracil (uracil, cytosine arabinoside (cytidine), hydroxyurea (urea).

Methotrexate is unique in the manner of its clinical administration, and presents a fascinating phenomenon. Methotrexate is not really selective, and is equally cytotoxic to normal and cancer cells, so that when the drug is administered, cells are indiscriminately "suspended". However, immediate treatment with a folic acid supplement, leucovorin (citrovorum factor), can "rescue" the cells before death; the extraordinary feature of this phenomenon is that only normal cells can be rescued—cancer cells cannot. Consequently, methotrexate treatment involves a continual cycle of treatment with drug, rescue, drug, rescue, etc. Methotrexate is an effective agent in a wide variety of malignancies, including acute lymphocytic leukemia, choriocarcinoma, and breast cancer.

Most antibiotics with anti-tumour properties originate as natural products, usually from microorganisms, and have been discovered in many different parts of the world, e.g. mitomycin C (Japan), variomycin A (Russia), bleomycin (Japan), and adriamycin (Italy). Compounds isolated from natural sources are often available in quantities too small for clinical testing; consequently, there is an enormous research effort being expended by organic chemists on the total synthesis of antibiotics. Many of these studies have also produced new variations on the natural structure; occasionally the synthetic analogue has improved anti-tumour properties. Antibiotics may act at various points in the sequence of replication, transcription, and protein synthesis, but most bind to the DNA molecule probably by "intercalation" in the double helix. Such binding to DNA can often be observed "in vitro" by means of a characteristic change in the u.v./vis. absorption spectrum of the drug molecule.

Adriamycin was first isolated in the late 1960's in Italy from a mutant strain of the microorganism *streptomyces peucetius.* Adriamycin is probably the best known of the antibiotics, and there is currently intense international interest in this drug, which has the widest spectrum of clinical activity of any known compound. Most significantly, adriamycin is active against a broad spectrum of *solid* tumours, many of which are poorly or non-responsive to other drugs. Adriamycin is clearly active against almost 50% of human tumours (for which treatment statistics are satisfactory) and clearly inactive in only 15%. Adriamycin is being used in a broad array of combination chemotherapy trials, and response rates as high as 80% have been reported. Like all anti-cancer drugs, adriamycin causes toxic side effects (nausea, vomiting, loss of hair), but the most limiting side effect is its toxicity to the heart. Considerable effort in research is being expended to try to overcome the cardiac irregularities associated with adriamycin.

The antibiotic adriamycin has the widest spectrum of anti-tumour activity of any known compound. It is clearly active against nearly half of human tumours. Most antibiotics bind to DNA molecules by "intercalation" (stacking between DNA base pairs), and thus interfere with the metabolism of bacterial and tumour cells. Like all anti-cancer drugs, adriamycin has limited specificity in its action, and large doses are toxic to normal heart cells.



Adriamycin

In order to undergo intercalation, antibiotic drugs must have a molecule with a flat section of the proper cross-sectional area, and be a positively charged ion at normal cell pH. Synthesis of new antibiotic compounds, differing slightly in structure from their natural analogs, is presently the focus of an enormous research effort.

Many known anticancer agents do not fall into the foregoing categories, and are grouped together as "miscellaneous". Hormonal compounds are among the oldest of anticancer drugs; male hormones are used against breast cancer, and female hormones for treating prostrate cancer. Many metal chelates or complexes exhibit cytotoxicity. One of the most potent, broad spectrum antitumour agents of this type is cis-dichlorodiaminoplatinum, which has been used in clinical trials. Other miscellaneous agents include procarbazine, maytansine, vincristine, and dacarbazine. Dacarbazine, otherwise known as DTIC (dimethyltriazenoimidazolecarboxamide) is the single most active agent in the clinical treatment of human malignant melanoma, but its mechanism of action is essentially unknown.

The major problem of cancer chemotherapy is the nature of the drugs, which are designed to destroy any cell which multiplies quickly. Because of the high toxicity of anticancer drugs, the amount of drug which one can give to destroy the cancer cells is limited. One approach to this problem is to give some direction, some specificity, to the drugs by bonding them to antibody molecules aimed against only

A new ammunition—Interferon—enters the war against cancer

After years of agonizingly slow progress in cancer research, there is a growing sense of excitement among medical specialists about a rare, extremely expensive, but promising new cancer drug: interferon, or IF, as it has been popularly christened. Hardly a week passes without some mention of interferon in the press. The substance that has caused all the excitement was discovered in 1957 by virologists Alick Isaacs and Jean Lindenmann in London, who shared an interest in a biological phenomenon known as viral interference, so called because the presence of one kind of virus in an organism inhibits infection by other viruses. In experiments with cells of chicken eggshell membrane in culture, they discovered that an initial virus infection stimulates the cells to produce a substance which "interferes" with further viral assaults. The substance remains behind in the culture medium when the original cells and viruses are removed. They called this mysterious substance *interferon.*

The anti-viral properties of interferon put it in the same class as the antibacterial agent penicillin: it seemed too good to believe. Early investigations with interferon were hampered by the minute quantities available and the cost of production. These liabilities are only now being overcome. The chemical is produced only in miniscule quanitities by living cells. Unlike insulin extracted from cattle and pig glands and used in humans, IF harvested from animals does not work in people. During the 1960's, a small group of interferon enthusiasts continued working with only the tiniest amounts of material, gradually unlocking interferon's secrets. IF is a protein, produced in a different form by three types of cells—leukocytes (white blood cells), fibroblasts (connective tissue in skin and other organs) and T lymphocytes (soldier cells that form part of the body's immune system).

These studies have also revealed much about the mechanism of interferon defence against viruses; interferon assumes the role of an intercellular messenger and warns healthy cells of the viral invasion. The healthy cells respond by producing antiviral proteins so that the entering virus will not be able to replicate within the new cell. In this way, the cycle of infection is broken.

The breakthrough in mass production of interferon was made in Finland by virologist Kari Cantell. He utilized byproduct white blood cells from blood collected and processed by the Red Cross. The leukocytes are infected with a virus, incubated at body temperature for 24 hours and then centrifuged to remove the white cells. The resultant solution is partially purified to destroy viruses. What remains is a highly impure IF preparation (0.1% purity). Further purification is prohibitively expensive and destructive, but researchers were provided with enough interferon to begin the first clinical trials. IF has been successfully used for treating the common cold, respiratory infections, shingles and chicken pox.

The possibility that some humans cancers might be associated with viruses influenced researchers to study the anti-cancer properties of interferon. One of the early reports of IF anti-tumour properties was made by Ian Gesser, in France, who demonstrated that IF actually prevented leukemia in mice that had been especially bred to develop it. In 1972, IF from Kari Cantell's laboratory was used by Hans Strander, a cancer physician in Stockholm. He treated children with osteogenic sarcoma, a rare and deadly form of bone cancer which kills almost 80% of its victims within two years using conventional treatments. Strander has now treated 44 of these patients with IF, after surgery. More than half are alive after five years, compared to less than 25% that did not get IF. Favourable results have been obtained from IF treatment of other cancers—juvenile laryngeal papillomatosis, advanced breast cancer and multiple myeloma.

By 1978, more and more people were becoming convinced of the potential of interferon, and the American Cancer Society provided several million dollars for interferon production and clinical trials. The big drive for IF had begun. The largest test of interferon ever conducted is underway right now in the US. Tiny quantities of the drug are being administered to some 70 patients, who were no longer responding to conventional treatment, with four different types of cancer.

Why does interferon work against cancer? Though viruses are suspect in some forms of human cancer, interferon also seems to work against tumours thought to be caused by non-viral agents such as radiation and chemicals. Scientists do know that IF inhibits the growth of both healthy and abnormal cells by slowing cell division. Unlike most cancer drugs, it does not kill malignant cells outright, but somehow alters them so they stop proliferating, and IF works best when cancer cells are dormant, rather than rapidly proliferating. Interferon also stimulates the general immune system. Questions still remain about the role and effectiveness of IF as a cancer drug, and these will only be answered if large amounts become available. Techniques for mass producing interferon may be developed over the next few years, easing the scarcity of IF which has frustrated IF researchers.

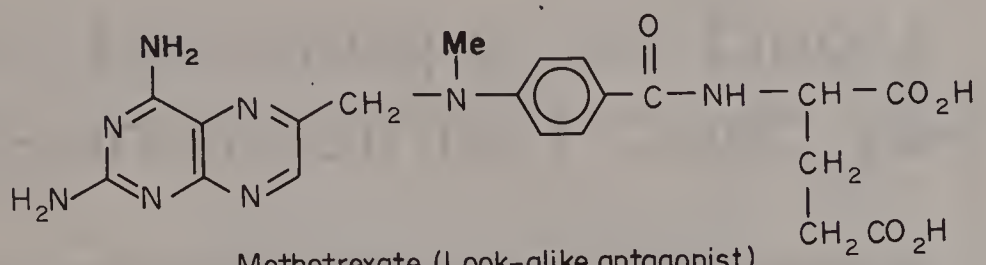
Perhaps the most promising avenue is the recombinant DNA technique being tried by BIOGEN and other companies. In this method, scientists chemically snip a gene containing the code for producing a certain protein from DNA of one organism. The gene is then chemically spliced into the DNA of another organism, usually a harmless laboratory strain of the common intestinal bacterium *Escherichia coli.* The genetically-programmed bug begins reproducing millions of identical offspring, each capable of producing the same protein. The cumulative output can be substantial and could ultimately provide the quantities that will be required.

Even IF's most fervent advocates warn against prematurely raising the hopes of cancer victims and their families. If interferon finally proves to be an effective cancer drug, there would still be a long way to go. Many years will pass before it becomes widely available and research may be only 2% of the way along the path to widespread clinical application. However, even if interferon should only partly live up to its inital, most tentative promise, it would augment the sparse arsenal so far developed to combat the world's most terrifying and psychologically daunting disease.

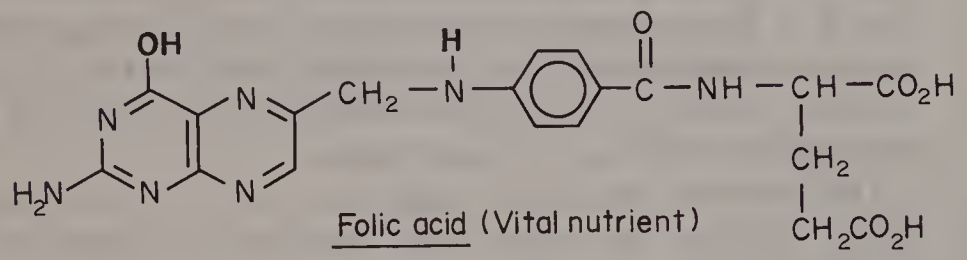
The preceding description of interferon is a precis of a recent article in "TIME Magazine" (March 31, 1980, Vol. 115 No 13, pp 46 -52)

Methotrexate is a "look-alike" antagonist. Because its structure is so similar to that of the essential vitamin folic acid, cancer cells cannot distinquish the two compounds. Of course, methotrexate cannot be metabolized in the same way. Thus, the normal metabolism of folic acid, which is essential for cell functioning and survival, is blocked.

An extraordinary feature of methotrexate is its method of clinical administration. The compound is equally toxic to normal and cancer cells. However, before the cells die, normal cells can be "rescued" by treatment with folic acid supplement, but cancer cells cannot. While the inital action of methotrexate is not specific, only normal cells survive alternating treatment with methotrexate and folic acid supplement.



Methotrexate (Look-alike antagonist)

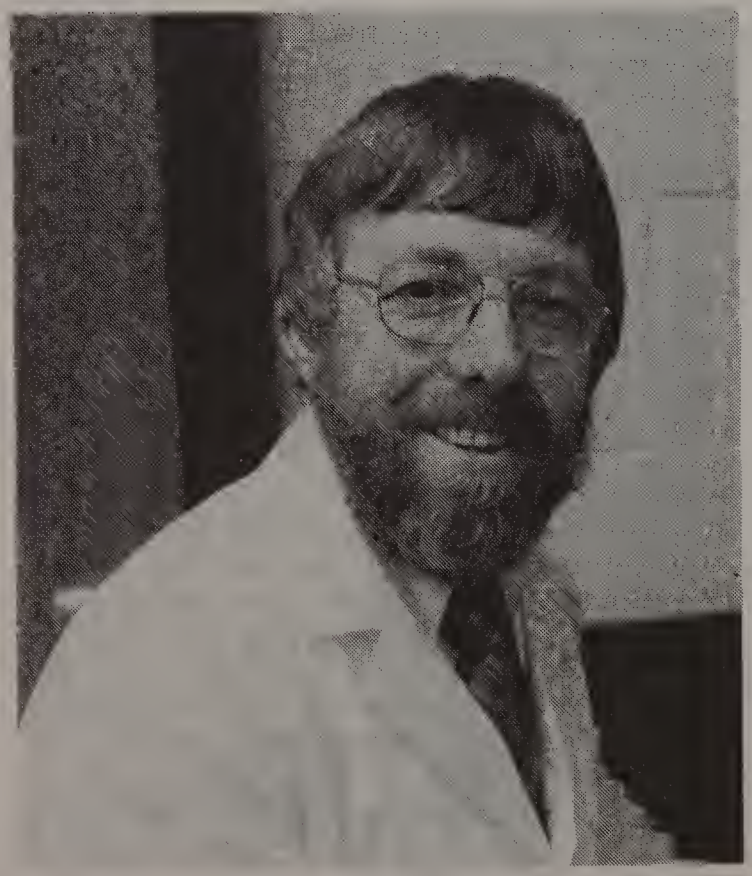


Folic acid (Vital nutrient)

cancer cell surfaces. Antibodies are very selective in their action, and therefore, one expects that a drug bound to antibody molecules will be carried to the tumour cells and not to normal tissues. The antibody is essentially the "homing device" for the drug molecule.

As well as increased selectivity, the association of a drug with an antibody carrier can also modify its mechanism of intracellular penetration. It can promote the cellular uptake of drugs that otherwise could not enter cells because of membrane impermeability. The chemoimmunotherapeutic approach to cancer treatment is in the early stages of development and holds much promise for the future.

Another approach to the problem of selectivity is to find drugs which work on the principle of converting cancer cells back to normal instead of killing them. Normal cells stop increasing in number when they touch one another; this "contact inhibition" is one aspect of cellular growth control which apparently is lacking in cancer cells. Some cancer researchers have been looking for drugs which would prevent cancer cells from multiplying and forming a lump when they come into contact with other cancer cells. A new drug called thioproline has recently been tested on 32 cancer patients in the northwestern Spanish city of Oviedo; fourteen patients responded, six with complete remission of the disease. There were no apparent side effects. Most of the patients who responded had squamous cancer of the head or neck, which is a form of cancer difficult to treat by other methods. Partial remissions were also observed in patients with lung, kidney, and breast cancer. When the patients stopped taking the drug, the cancers reappeared. Although the mechanism of thioproline action is not yet well understood, it appears to act by a form of "reverse transformation", whereby the contact inhibition mechanism is restored and the cancer cells stop growing. Reverse transformation of certain types of cells is not a new phenomenon, but application of this principle to cancer treatment is very new. Further demonstration of the efficacy of drugs like thioproline represent an exciting prospect for cancer research, and "may be the most significant advance since the discovery of methotrexate in 1948."



About the author:

Keith Vaughan is chairman of the chemistry department at Saint Mary's University (Halifax, Nova Scotia B3H 3C3 Canada), where he becomes Associate Professor on September 1st. He is also Adjunct Professor of Graduate Studies at Dalhousie University (also in Halifax). His current research interests include synthesis of heterocyclic nitrogen compounds, synthesis and mechanisms of action of anti-tumour agents, open-chain triazenes, environmental toxicology and drug-binding to antibodies (targeted molecules for cancer therapy). He teaches Organic Chemistry and Biochemistry, and is interested in self-paced teaching (Keller Plan) applied to General Chemistry.

Liquid fuel is produced from waste by direct thermochemical reaction

Virtually any organic waste or biomass material can be converted directly into an oil by heating small particles with water and alkali to temperatures up to 350°. The oil product has a higher heating value than the starting material (i.e. it is more energy concentrated), but it contains some high molecular weight materials and some corrosive phenols. By using standard distillation methods, this oil can be easily converted into a fuel, a source of chemicals, and asphalt additives or substitutes.

The process disposes of organic wastes such as sewage, trash and wood waste, and at the same time, provides a simple and elegant means of creating liquid fuel and organic chemicals.

by Dr. Peter M. Molton
Battelle Pacific Northwest Laboratories

Two of the most pressing problems facing humanity today are pollution of our planet by wastes, and deriving sufficient energy to power our civilization. These two problems may be confronted simultaneously by using plant wastes to make energy. Various techniques can be used, including direct burning, fermentation to alcohol, gasification and liquefaction.

Most available wastes (municipal trash, forestry residues, human and animal sewage and manure, food processing waste) contain relatively large amounts of water. Simple calculations show that if a waste contains more than about 80% water, more heat will be required to remove the water by distillation than can be recovered by combustion of the carbon fraction of the waste. Even to remove lesser amounts of water still requires energy which would otherwise be available for work. An average potato contains 80% water, sewage over 90%, and wood wastes characteristically contain up to 50% water. If there were some way to separate water from biomass-derived fuels before combustion, then the energy gain would be very significant. In fact, there is such a way.

Of the various methods of making fuels from biomass, only two—fermentation, and direct thermochemical liquefaction—do not involve prior drying of the biomass feedstock. Fermentation is, by far, the most commonly used. Microbial conversion of sugar to alcohol is now attracting wide interest for producing fuel from agricultural waste (forthcoming article *Chemistry International,* 1980, No.5). However, yeast cells can only metabolize sugars and carbohydrate hydrolysis products of cellulose and hemicellulose; they leave the lignin content of waste (which has the highest fuel value) not only untouched, but heavily diluted with water and yeast cells. By contrast, direct thermochemical liquefaction (DTL) converts all available residue into product oil.

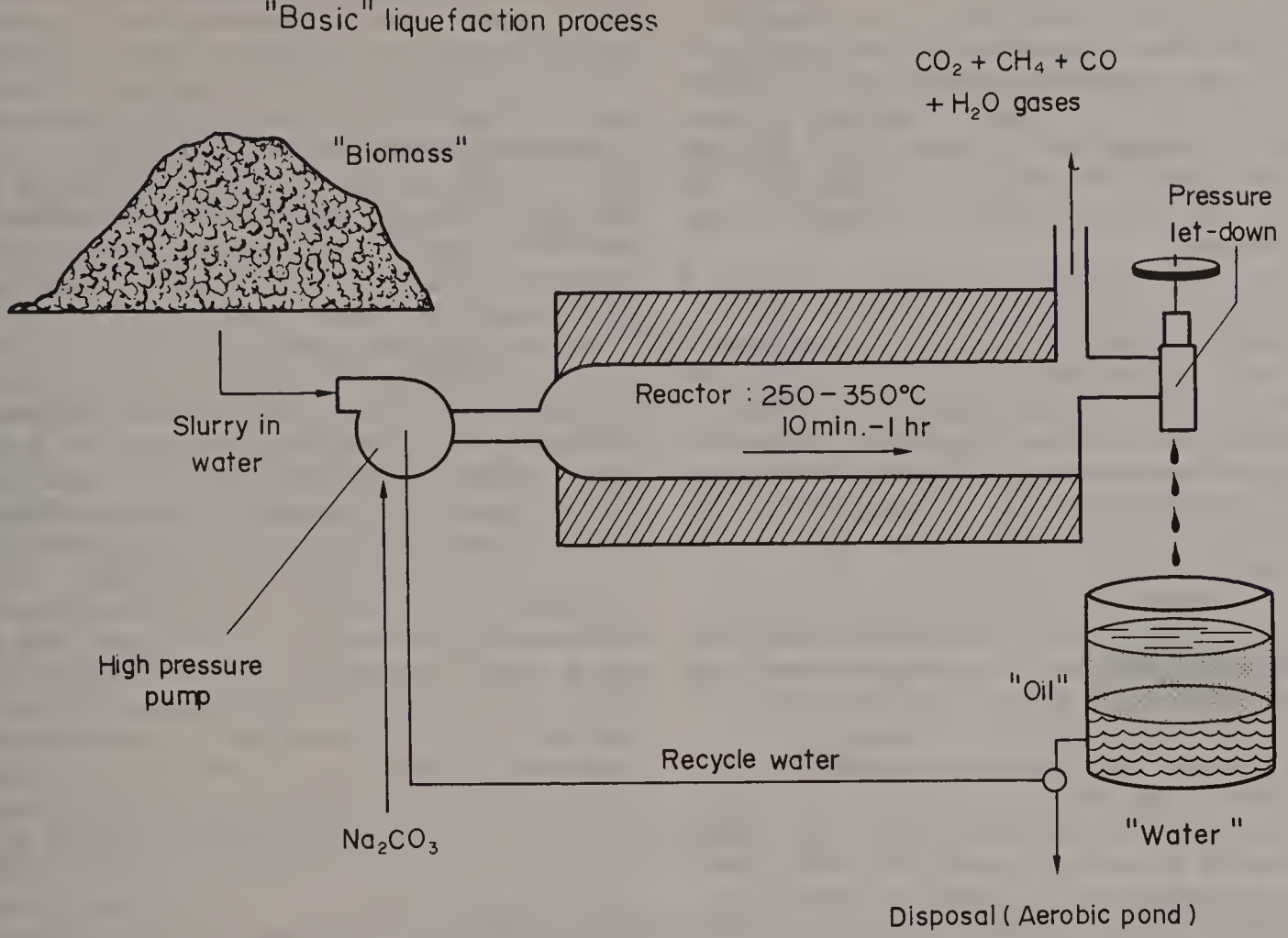
What is Direct Thermochemical Liquefaction, and why is it so efficient? The process consists essentially of heating biomass particles in water with a mild alkali. The waste feed is pumped into the reactor as a slurry containing 12-20% biomass solids, sodium carbonate is added to adjust the pH over 9, and the slurry is heated at 250-350°C for 10 minutes to 1 hour.

Because the biomass particles are suspended in water (superheated well above its normal boiling point), high steam pressure develops in the reactor. Furthermore, an offgassing reaction at 265° releases carbon dioxide, as well as minor amounts (1% or less) of carbon monoxide, methane and hydrogen. During the reaction, steam and gas pressure reach about 12 MPa (120 times atmospheric pressure). This high pressure imposes stringent requirements on the feed pump. It must operate against this pressure, but also must not be damaged by large slurry particles or dirt.

The reaction forms a product oil which is immiscible with water. After separation from the water by decantation or centrifugation, the oil contains only 10-15% water. The water layer, containing only 5% of the organic products, is mixed with fresh waste and recycled.

The viscous oil product can be upgraded to motor fuel or heating oil. It has a heating value of about 30-35 kJ/gram, compared to crude petroleum heating values of about 40 kJ/g. By contrast, the specific heating value of the original cellulose-containing waste is only about 15 kJ/g when completely dry.

During formation of the oil within the reactor, water is ejected (as well as carbon dioxide) from the



In the simplest form of direct thermochemical liquefaction, shredded biomass is slurried with water and fed into the reactor by a high pressure pump. At slurry concentrations below 12%, the energy in the oil product is insufficient to offset heating and process losses, while at concentrations over 20% the feed becomes too viscous to pump. Sodium carbonate is added to a concentration between 0.1-1.6 N, and the mixture is heated to 250-350° for up to one hour. After exiting the reactor, the oil product separates from the water in a collection tank.

The process, depicted in the diagram above, is studied in laboratory-scale experiments using small (180 ml) rocking autoclaves.

molecular structure of cellulose. It is primarily the release of water during direct thermochemical liquefaction that is responsible for the product oil's much higher heating value than the feed material. Cellulose, the major organic component of most forms of biomass, has the formular $(C_6H_{10}O_5)_n$ and contains about 50% oxygen by weight. By comparison, the oil product generally contains less than 12% oxygen.

Direct thermochemical liquefaction provides a very high overall energy conversion efficiency, although the oil yield is only about 35% the weight of the waste feed. In theory, the yield of hydrocarbons made from cellulose could be as much as 53%. This calculated yield would not be appreciably affected if lignin and hemicellulose were present in the biomass feed, as well as cellulose. So, the actual yield of 35% corresponds to 66% of (the fraction 35/53) of the theoretical oil output *by weight.*

If we consider the *energy* content of the oil product, it amounts to more than 60% the combustion energy of the waste feed. No other process can, to the author's knowledge, convert a wet feedstock to liquid fuel with such high energy recovery.

Surprisingly, direct thermochemical liquefaction is not a new process. Far from it. It was known at least a century ago that oils could be made by alkaline digestion of biomass. However, most early applications were in the paper pulp industry, and most work was done when fuel was plentiful and cheap. Use of DTL for making a petroleum substitute was generally not considered. In fact, the process attracted attention chiefly because it was thought to be related to the natural conversion of biomass to coal. However, direct thermochemical liquefaction stops short of making a solid coal-like product.

A modified version of the basic DTL process is based on the discovery, originally made in 1924, that the oil yield is significantly increased by a carbon monoxide overpressure. Recent work at the US Bureau of Mines have confirmed this observation, but in order to raise the oil yield from 35 to 58% requires that CO and hydrogen must be added at pressures at least 100 atmospheres higher than that otherwise present in the reactor. Equipment required to generate CO from biomass and inject it into the reactor makes the process more expensive and complicated. This must be weighed against the increased yield when considering the economics of the process.

At present, only the crudest estimates of process costs are available. It appears that oil may be made with CO addition for about US$26/barrel, and by the simpler process without CO addition for about US$20/barrel. This outlook could change rapidly, if for instance, a good liquefaction catalyst were to be found. No commercial plants are presently operating using either the DTL direct process or the DTL-with CO process. However, a 3 ton/day pilot plant is operating at Albany, Oregon (USA) using the DTL-with CO process.

It is presently not possible to say which of the 2 process variants is best, but this judgement will depend in any case on regional factors not related to chemistry—such as the availability and cost of biomass, its water content, and the technical sophistication of the country where the plant is built.

In principle, the basic DTL process requires only a high-pressure feeder, tube reactor, let-down (pressure release), and possibly a small centrifuge. This "basic" process is possibly best suited for small-scale farm units. It might take raw animal manure as its feedstock, and with minimal dewatering, convert this to diesel fuel (for powering tractors) or to heating oil. Although DTL is certainly more difficult to perform than anaerobic digestion for farm-scale applications, it may prove to be more economic, but this remains to be proven in practice.

The more complex Albany (COSTEAM) process requires production of carbon monoxide and hydrogen, partial product recycle, and an additional preheating step. It might be best suited for large-scale, highly sophisticated chemical engineering plants, making large quantities of fuel but suffering from high transportation costs of its low-grade feed.

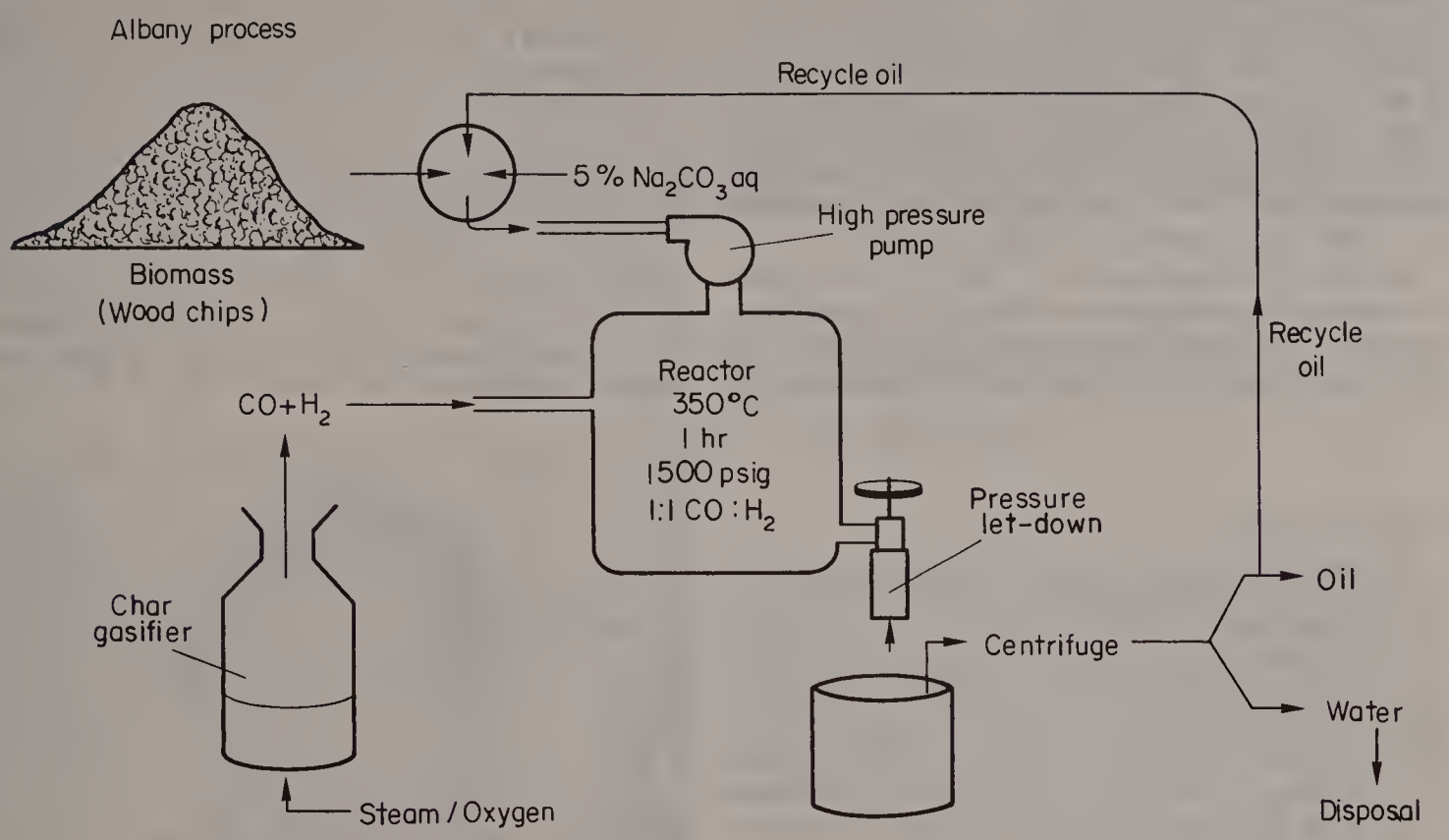
What about quality of the oil product? Like petroleum crude, it will have to be refined before it can be used in the average boiler or engine. This of course adds additional cost to the final product, making the economics even more tenuous. We have examined the physical and chemical properties of crude oils generated from pure cellulose, hop residue and pine wood. We find that they uniformly contain phenols, furans, ethers, alcohols, aldehydes and ketones, as well as a higher molecular weight (up to 13 000) fraction which appears to be primarily condensed aromatics. Simple vacuum distillation gives 2 fractions: an oil containing phenols and other low molecular weight materials, and a higher molecular weight fraction which we are now investigating as a low-cost asphalt additive. Removal of phenols from the light oil fraction yields a liquid which can be used as diesel fuel or chemical feedstock. Biomass oils are perhaps most analogous to coal tar, except of course, biomass oils are very low in sulfur and nitrogen.

In our analysis of biomass-derived oils, we have so far identified 85 compounds. Apart from the phenols, no acidic or other corrosive materials have been found. The oils tend to precipitate a black polymer on standing, which we believe is formed by reaction between phenols and furans or ketones. Removal of the phenols would therefore stabilize the oil and permit it to be stored. The remaining material should be a high-grade fuel, since its heating value is nearly 80% that of diesel fuel.

Even without further refining, over 45% of the crude oil product derived from cellulose consists of aromatic compounds. The amount of aromatics can be enhanced even further by hydrogenation. This converts some of the tarry asphaltenes to low molecular weight (primarily aromatic) hydrocarbons. Hydrogenation would similarly convert phenols to aromatic hydrocarbons.

We are currently investigating the possible construction of a reliable, continuous unit for manure liquefaction on a 400 litre/day scale. This would allow us to realistically assess the possibilities for larger on-farm units, capable of utilizing wastes from a minimum of 50 cattle. The units would make farm operation more efficient by providing a local fuel supply for tractors, and at the same time, remove an obvious source of pollution.

It should be mentioned that DTL—or any form of



The oil yield can be increased from about 33% by weight, up to 58% (approaching the theoretical yield) by introducing carbon monoxide and hydrogen at high pressure.

To test the process on a continuous 3 ton/day basis, a pilot plant (shown here) has been built in Albany, Oregon (U.S.A.). It was originally designed to use dried wood chips as biomass feed, admixed with 5% aqueous sodium carbonate and recycled oil product (initally simulated by anthracene oil). The feed was preheated before entering the main reactor, and the product oil mixture was to be separated by a centrifuge. Carbon monoxide and hydrogen are obtained from tanks for pilot plant studies, but in a commercial plant, they would be obtained by gasification of char and/or biomass.

Corrosion and product polymerization problems have led to major design changes in the pilot plant. Instead of recycled oil, the vehicle is now water. An acid prehydrolysis step allows the biomass content of the slurry to be increased to 30%. The centrifuge was ineffective, and the preheating step is no longer used. Most of these changes have yet to be fully tested under actual operating conditions.

biomass liquefaction or conversion (including direct burning)—would have local, rather than world-wide, impact. In the USA, most estimates of biomass fuel production range from 10 to 15% of current energy consumption. But direct thermochemical liquefaction produces liquid fuels for transportation and heating, and these are applications in which substitute fuels are most critically needed.

In any case, production of fuel by direct thermochemical liquefaction of biomass is a promising approach, and certainly deserves more attention in the research arena than it has so far been given. To assist in its development, we will be happy to share our research results with others who wish to promote DTL processes.

Acknowledgement:

Basic research on chemical mechanisms involved in biomass liquefaction undertaken by the author's group was supported entirely by the U.S. Department of Energy, Division of Chemical Sciences, Office of Basic Energy Sciences (under operating contract number EY-76-C-06-1830). They gratefully acknowledge this support.

About the author:

Dr. Peter Molton's present research into the conversion of biomass waste by thermochemical methods follows years of study into how bacteria approach the same problem. After completing his PhD in Organic Chemistry (granted by Queen Elizabeth College, London in 1967) working on hydrocarbon degradation by bacteria, Dr. Molton moved to the Microbiology Department of the same college. There, he did a three-year post-doctoral project on methane oxidation by bacteria. For this work, he received a Masters degree in Microbiology in 1971.

In the same year, Dr. Molton moved to the USA for a one-year National Academy of Sciences Fellowship at Ames Research Center in California, and then to the University of Maryland for the period 1972-1975. At both places, he worked on the origin of life problem.

In 1975, he started work at the Battelle Pacific Northwest Laboratories, where Dr. Molton is now Group Leader, Sciences, of the Food and Agriculture Section. His work includes the determination of waste conversion chemistry, as described in this article. He is also involved with microalgae as a basic food and energy source. Dr. Molton would like to communicate with researchers in other countries who are also investigating direct thermochemical liquefaction. Comments can be addressed to Dr. Molton at the Chemical Technology Department, Battelle Pacific Northwest Laboratories, P.O. Box 999, Richland, Washington 99352 U.S.A.

A pioneer of nomenclature dies; a chemical society is born

Nomenclature is not a popular topic attracting great prizes, so Pieter Eduard Verkade received few. Many chemists have never heard his name, although he was a major force shaping the terminology used by chemists throughout the world. Until his recent death, Prof. dr. Verkade performed an active and vital role in IUPAC Committee work for nearly *50* years. His efforts were a major element steering the development of IUPAC, as well as the language of chemists. Here, a few highlights of Prof. Verkade's lifetime work on chemical nomenclature are summarized by Dr. L. C. Cross, a member of the Commission on Nomenclature of Organic Chemistry.

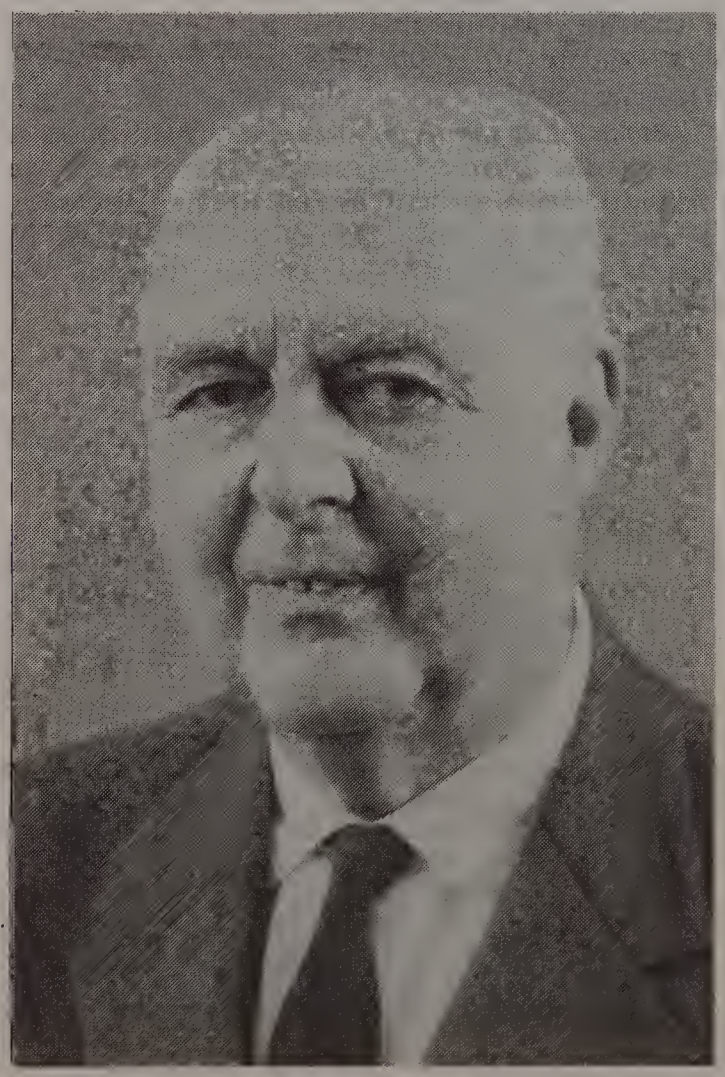
It is seldom that a scientist, bent on the discovery of scientific truth, is much concerned with obscurities of specialised language in which that truth is expressed. Pieter Eduard Verkade was one such exception.

Verkade was born in Zaandam (the Netherlands) in 1891 and died in the Hague on 17 September 1979. His first degree was obtained in 1913 as a pupil of J. Boeseken. During that apprenticeship, his interest was awakened to the need, particularly in teaching, for careful and accurate expression of scientific facts and ideas. It was therefore not surprising that Boeseken, in 1922, introduced Verkade to international efforts then being made to revise and extend organic nomenclature proposed at Geneva in 1892. The revisions appeared after the 1930 meeting of the IUC (later to be re-entitled as IUPAC) at Liège, leading to the so-called "Liege Rules". It was later supplemented by reports from meetings at Lucerne in 1936 and at Rome in 1938.

At the first post-war meeting of IUPAC in London in 1947 it was apparent that the Rules of Organic Nomenclature needed once again to be extended and revised. Again, Verkade was called on to take up this arduous task. Over the following 25 years, the whole area of naming compounds in "Classical" organic chemistry and many areas of specialized chemistry were dealt with in an integrated set of some 1000 rules—all masterminded by Verkade—"the IUPAC Rules of Nomenclature of Organic Chemistry".

In all, his involvement with IUPAC Committee work continued for a total of 49 years, 37 of them as Chairman of the Commission for the Nomenclature of Organic Chemistry.

Verkade brought to this task not only a love for this type of problem, but also a profound knowledge of "classical" chemistry, a life-time of teaching experience, and a love of languages other than his mother-tongue. In technical discussion, his commission could always depend on his knowledge of chemical fact. His teaching background persuaded him never to accept nomenclature based only on



theoretical concepts, and he insisted that any usage was compatible with the several languages commonly used in the scientific world.

Late in his active career Verkade realised that he alone could document adequately the history of chemical nomenclature work and he did this in 16 papers, "Etudes historiques sur la nomenclature de la chimie organique" all appearing in *Bulletin de la Societe chimique de France* between 1966 and 1979.

The international honour that gave Prof. Dr. Verkade much pleasure was the Austin Patterson Award by the American Chemical Society in 1973. But his greatest memorial must be the "Blue Book", *Nomenclature of Organic Chemistry.**

On June 1st, two of the oldest chemical societies—both thriving organizations that were well-known and respected in the world chemical community—ceased to exist. The disappearance of the Chemical Society (CS) and the Royal Institute of Chemistry (RIC) as separate organizations was accompanied by the creation of a new integrated society, representing the 40 000 chemical scientists in the United Kingdom—**the Royal Society of Chemistry** (RSC).

Since their formation, the Chemical Society (granted its charter in 1848) and the Royal Institute of Chemistry (dating from 1885) have always been closely associated. Since 1972, they have advanced towards greater collaboration and a common membership. Establishment of the Royal Society of Chemistry marks the final step in a gradual movement towards complete integration. The new Royal Society of Chemistry will undertake the functions previously performed by the two original organizations. Its main objectives are to advance the science of chemistry and its applications, and to maintain high standards of competence and integrity among practising chemists (not including pharmacists).

Secretary General of the new Society is Mr. John Ruck Keene (formerly General Secretary of the Chemical Society), while Dr. Eric Parker (previously Secretary and Registrar of the Royal Institute of Chemistry) serves as Registrar and Secretary for Public Affairs.

Almost exactly one month after the Royal Society of Chemistry officially came into existence, the Federation of European Chemical Societies (FECS) celebrated its tenth anniversary. The Federation now has 30 member chemical societies from 24 countries, embracing almost the whole of Europe. During the last decade, seven Working Parties have been established dealing with special aspects of chemistry as a science or as a profession.

The Federation or its Working Parties have initiated a number of conferences, and has granted FECS sponsorship to outstanding national and international events organized by member societies. In addition, FECS has organized several FECHEM conferences dealing with very specialized topics of chemistry.

The Federation maintains good relations with IUPAC and other international bodies. It has, for example, carried out joint projects with UNESCO.

To commemorate the 10th anniversity of the Federation, an annual lectureship has been established. The first FECS lecture will formally be presented on 11 June 1980 in Frankfurt am Main (Federal Republic of Germany) by Nobel laureate Prof. Sir Derek Barton (presently an elected member of the IUPAC Bureau). The Lectureship will be awarded once each year to a prominent chemist from a European country. The Lecturer will be invited to tour European countries represented by FECS member societies, and will be offered travel expenses, accommodation and an honararium.

The Israeli Chemical Society notified us that their offices have been moved to a new address: 66, Nordau Blvd, Tel-Aviv, Israel (telephone 252743).

**The most recent edition of "Nomenclature of Organic Chemistry" was published in 1979. The 550 page hardcover volume is published by Pergamon Press, Oxford, UK.*

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1980

TOXICOLOGY OF NICKEL

September 3 - 5 2nd Int. Conference on Environmental & Occupational Toxicology of Nickel. Swansea, U.K. (Prof. F. W. Sunderman Jr., Dept of Laboratory Medicine, University of Connecticut, P.O. Box G, Farmington, Connecticut 06032, U.S.A.)

EUROCOATINGS '80

September 4 - 5 2nd European Conference on Paints & Coatings. Frankfurt, Federal Republic of Germany.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada)

SOLVENT EXTRACTION

September 6 - 12 Int. Solvent Extraction Conference. Liège, Belgium.
(Secretary ISEC '80, Dept. of Chemistry, University of Liège, Sart Tilman, B-4000 Liège, Belgium)

COAL AS A CHEMICAL FEEDSTOCK

September 7 - 11 Int. Conference on Coal as a Feedstock for the Chemical Industry. Sheffield, U.K.
(Dr. E. Rothwell, Dept. of Chemical Engineering and Fuel Technology, University of Sheffield, Mappin Street, Sheffield S1 3JD, U.K.)

ANALYTICAL CHEMISTRY/SPECTROSCOPY

September 7 - 12 7th Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies. Philadelphia, Pennsylvania, U.S.A.
(J. A. Williamson, Dupont Co., Instrument Products Div., Wilmington, Delaware, U.S.A.)

MACROMOLECULES

September 7 - 13 Int. Symposium on Macromolecules. Florence, Italy.
(Prof. F. Ciardelli, Istituto Chimica Organica Industriale, Via Risorgimento 35, I-56100 Pisa, Italy)

PHOTOSYNTHESIS

September 7 - 13 5th Int. Congress on Photosynthesis. Greece.
(Dr. G. Akoyunoglou, IPC Dept. of Biology, Nuclear Research Center Demokritos, Aghia Paraskevi, Athens, Greece)

GAS DISCHARGES

September 8 - 11 6th Int. Conference on Gas Discharges and Their Applications. Edinburgh, Scotland.
(The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, U.K.)

GAS FLOW & CHEMICAL LASERS

September 8 - 12 3rd Int. Symposium on Gas Flow and Chemical Lasers. Marseille, France.
(G.C.L. Symp. Sec., Institut de Mécanique des Fluides, 1 rue Honnorat, F-13003 Marseille, France)

INHALED PARTICLES

September 8 - 12 5th Int. Symposium on Inhaled Particles. Cardiff, U.K.
(D. A. Phillips, Joint Organizing Secretary, MRC Pneumoconiosis Unit, Llandough Hospital, Penarth, Glamorgan, U.K.)

WORLD ENERGY

September 8 - 12 11th World Energy Conference. München, Federal Republic of Germany.
(Dr. E. Ruttley, WEC, Intern. Executive Council, c/o British National Committee, 34 James Street, London SW1A 1HD, U.K.)

INFRARED SPECTROSCOPY

September 8 - 12 6th Int. Seminar on High Resolution Infrared Spectroscopy. Liblice, Czechoslovakia.
(Dr. D. Papoisek, The J. Heyrovsky Institute of Physical Chemistry and Electrochemistry of the CSAV, Vlasska 9, CS-11840 Praha 1, Czechoslovakia)

FIRE RETARDANTS

September 9 - 10 4th European Conference on Flammability and Fire Retardants. Frankfurt, Federal Republic of Germany.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada)

CANCER

September 10 - 13 Int. Symposium on Cancer—Environment and Geocancerology. Besançon, France.
(Prof. P. Tran Ba Loc, Faculté de Médecine et de Pharmacie, 4 Place Saint Jacques, F-25000 Besançon, France)

CRYSTAL GROWTH

September 10 - 16 6th Int. Conference on Crystal Growth.
September 17 - 25 4th Int. Specialists School on Crystal Growth. Moscow, U.S.S.R.
(Dr. E. I. Givargizov, Institute of Crystallography, USSR Academy of Sciences, Leninskii Prosp. 59, SU-117333 Moscow, U.S.S.R.)

OXYGEN

September 15 - 18 2nd BOC Priestley Conference (Theme: production, storage and transport of oxygen in living systems and industry), Birmingham, U.K.
(Dr. John F.Gibson, Assistant Secretary (Scientific & Educational), The Chemical Society, Burlington House, London W1V 0BN, U.K.)

CORROSION INHIBITORS

September 15 - 19 5th European Symposium on Corrosion Inhibitors. Ferrara, Italy.
(Corrosion Study Centre, 'A Dacco' University of Ferrara, Via L Borsari 46, I - 44100 Ferrara, Italy)

MEDICINAL PLANTS

September 15 - 19 4th Asian Symposium on Medicinal Plants and Spices. Bangkok, Thailand.
(Dr. Vichai Reutrakul, Dept. of Chemistry, Faculty of Science, Mahidol University, Rama VI Rd., Bangkok 4, Thailand)

SAFETY IN PROCESS INDUSTRIES

September 15 - 19 3rd Int. Symposium on Loss Prevention and Safety Promotion in the Process Industries. Basle, Switzerland.
(European Federation of Chemical Engineering, 3rd Int. Symposium on Loss Prevention and Safety Promotion in the Process Industries, P.O. Box 141, CH-4007 Basle, Switzerland)

FLUORINE CHEMISTRY

September 15 - 19 7th European Symposium on Fluorine Chemistry. Padua, Italy.
(Prof. G. P. Gambaretto, Istituto di Chimica Industriale della Facoltà di Marzola 9, I-35100 Padua, Italy)

POLYMER NETWORKS

September 15 - 20 7th Discussion Conference on Polymer Networks. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelín, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

CONFERENCES 1980

APPLICATION OF CHROMATOGRAPHY
September 16 - 19 6th Int. Symposium, Advances and Application of Chromatography in Industry. Bratislava, Czechoslovakia.
(Herrn Dr. Jan Remen, Analytical Sekica CS VTS pri n.p. Slovnaft, Czechoslovakia - 82300 Bratislava)

MARINE NATURAL PRODUCTS
September 16 -20 3rd Int. Symposium on Marine Natural Products. Brussels, Belgium.
(Dr. J. C. Braekman, Faculté des Sciences, Avenue F.D. Roosevelt 50, Université Libre de Bruxelles, B-1050 Bruxelles, Belgium)

CRYSTAL DEFECTS
September 17 - 21 3rd Europhysics Topical Conference on Lattice Defects in Ionic Crystals. Canterbury, U.K.
(The Secretary, Europhysics Topical Conference, Physics Laboratory, The University, Canterbury, Kent CT2 7NR, U.K.)

NATURAL PRODUCTS
September 21 - 27 12th Int. Symposium on Chemistry of Natural Products. Tenerife, Spain.
(Prof. A. G. González, Instituto de Productos Naturales, Carretera la Esperanza 2, La Laguna, Tenerife, Spain)

ASTRONAUTICAL CONGRESS
September 21 - 28 31st Int. Astronautical Congress. Tokyo, Japan.
(International Astronautical Federation, 250 Rue Saint-Jacques, F-75005 Paris, France)

COSMETICS RESEARCH
September 22 - 25 11th Int. Congress on Cosmetic Research and Technology. Venice, Italy.
(Conventions Service Italy, Piazza Mignarelli 4, I-00187 Rome, Italy)

ELECTROCATALYSIS AND CHEMISORPTION
September 22 - 26 Generation and Role of Electrical Potentials in Biological & Model Membranes. Venice, Italy.
(Professor E. Vecchi, Consiglio Nazionale delle Richerche, P.O. Box 1075, I-35100 Padova, Italy)

SURFACE CHEMISTRY
September 22 - 26 8th Int. Vacuum Congress/4th Int. Conference on Solid Sufaces. Cannes, France.
(1980 Steering Committee, Societé Française du Vide, 19 Rue du Renard, F-75004 Paris, France)

POLYMERIZATION OF HETEROCYCLES
September 22 - 26 21st Prague Microsymposium on Ring- Opening Polymerization of Heterocycles. Karlovy Vary, Czechoslovakia.
(Dr. P. Cefelin, PMM Secretariat, Institute of Macromolecular Chemistry, 1888 Petriny, Prague 6, Czechoslovakia)

CLATHRATE COMPOUNDS
September 22 - 26 1980 Int. Symposium on Clathrate Compounds and Molecular Inclusion Phenomena. Jachranka Warsaw, Poland.
(Dr. Janusz Lipkowski, Instytut Chemii Fizycznej, Polska Akademia Nauk, ul- Kasprzaka 44/52, Poland - 01-224 Warszawa)

CHEMICAL PATHWAYS IN THE ENVIRONMENT
September 22 - 26 European Conference on Chemical Pathways in the Environment. France.
(Dr. C. Troyanowsky, Société de Chimie Physique, 10 Rue Vauquelin, F-75005 Paris, France)

SYNTHESIS OF NEW ELEMENTS
September 23 - 27 Int. Symposium on the Synthesis and Properties of New Elements. Dubna, U.S.S.R.
(Prof. Yu.Ts. Oganessian, Laboratory of Nuclear Reactions Joint Institute for Nuclear Research, Head Post Office, Box 79, SU-101000 Moscow, U.S.S.R)

FRESH WATER FROM THE SEA
September 23 - 27 7th Int. Symposium on Fresh Water from the Sea. Amsterdam, Netherlands
(Prof. A. A. Delyannis, Plastria St. 3, Pefki, Greece)

PHARMACEUTICALS & COSMETICS
September 24 - 26 4th European Seminar on Quality Control in the Pharmaceutical and Cosmetics Industries. Geneva, Switzerland.
(Administration Secretariat, Postfach 182, CH-4013 Basel, Switzerland)

WATER IN BIOLOGICAL SYSTEMS
September/October. Int. Meeting on "The Structure and Physical Properties of Water in Biological Systems". Yugoslavia.
(Dr. S. Maricić, National and University Library, Marulićev trg 21, P.O. Box 550, YU-41001 Zagreb, Yugoslavia)

WATER POLLUTION CONTROL
September 28 - Oct. 3 Water Pollution Control Federation Int. Convention. Atlantic City, New Jersey, U.S.A.
(R. A. Canham, 3900 Wisconsin Avenue, NW, Washington, DC 20016, U.S.A.)

SUN AND CLIMATE
September 30 - Oct. 3 Int. Conference on the Sun and Climate. Toulouse, France.
(Centre National D'Études Spatiales, Département des Affaires Universitaires, 18 avenue Édouard-Belin, F-31055 Toulouse Cédex, France)

THE ROLE OF FOOD SCIENCE
October 3 Symposium on the Role of Food Science and Technology in Social and Economic Development. Valencia, Spain.
(Dr. S. Barber, IATA, Jaime Roig 11, Valencia 10, Spain)

PHYSICS OF FLOW
Sept. 30 - Dec. 5 Autumn Course on Physics of Flow in the Oceans, Atmosphere and Deserts. Trieste, Italy.
(International Centre for Theoretical Physics, P.O. Box 586, 1-34100 Trieste, Italy)

ALCOHOLS
October 5 - 8 4th Int. Symposium on Alcohols, and other Biomass Fuels Technology. Guaruja-State of Sao Paulo, Brazil.
(Instituto De Pesquisas Tecnologicas—IPT, 4th International Alcohol Symposium, Caixa Postal 7141, 01000 - Sao Paulo, Brazil)

ATMOSPHERIC CORROSION
October 5 - 10 Int. Symposium on Atmospheric Corrosion. Florida, U.S.A.
(W. H. Ailor, Symposium Chairman, Metallurgical Research Division, Reynold Metal Co., Richmond Virginia 23261, U.S.A.)

DRUG METABOLISM
October 5 - 10 7th European Workshop on Drug Metabolism. Zürich, Switzerland.
(Administration Secretariat, Postfach 182, CH-4013 Basle, Switzerland)

ENERGY AND THE FOOD INDUSTRY
October 6 - 8 Int. Symposium on Energy and the Food Industry. Madrid, Spain.
(CIIA, BP 470-08 F-75366 Paris Cédex 08, France)

CHEMICAL DATA
October 6 - 9 7th Int. CODATA Conference. Kyoto, Japan.
(Committee on Data for Science and Technology (CODATA), Exec. Sec. Bertrand Dreyfus, 51 Boulevard de Montmorency, F-75016 Paris, France)

RADIONUCLIDES IN THE ENVIRONMENT
October 6 - 10 Int. Symposium on the Impacts of Radionuclide Releases into the Marine Environment. Vienna, Austria.
(Mr. Robert Najar, Conference Service Section, International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria)

POLYNUCLEAR AROMATIC HYDROCARBONS
October 7 - 9 5th Int. Symposium on Polynuclear Aromatic Hydrocarbons. Ohio, U.S.A.
(Dr. Ay. Bjorseth, Battelle Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201, U.S.A.)

CONFERENCES 1980/1981

SCIENTIFIC DATA
October 8 - 11 7th Int. CODATA Conference. Kyoto, Japan.
(Dr. Y. Mashiko, c/o Japan Society for CODATA, Dai-ichi Kanamori Bldg. 1-5-31 Yushima, Bunkyo-ku, Tokyo 113, Japan)

PESTICIDES AND ARTIFICIAL FERTILIZERS
October 12 - 16 Int. Conference on Pesticides and Fertilizers—Man and the Environment. UNESCO Programme "Man and the Biosphere". Varna, Bulgaria.
(Dr. Todor Popov, Secrétaire Général du Comité d'Organization, Institut d'hygiène et de maladies professionnelles, Sofia 1431, Bulgaria)

CATALYST DEACTIVATION
October 13 - 15 Int. Symposium on Catalyst Deactivation: Poisoning, Coke formation, Solid state chemical transformations. Antwerp, belgium.
(International Symposium "Catalyst Deactivation", Technologisch Instituut—K. VIV, Jan Van Rijswijcklaan 58, B-2000 Antwerpen, Belgium)

SCIENTIFIC INFORMATION TRANSFER
October 13 - 17 2nd Int. Conference of Scientific Editors. Amsterdam, Netherlands.
(Helena Tombal, Elsevier Scientific Publishing Co., P.O. Box 330, NL-1000 AH Amsterdam, Netherlands)

ELECTROCHEMISTRY
October Electrochemical Society Int. Convention. Miami beach, Florida, U.S.A.
(M. A. Fahner, P.O. Box 2071, Princeton, New Jersey 08540, U.S.A.)

WATER CHEMISTRY OF NUCLEAR REACTORS
October 13 - 17 Int. Conference on Water Chemistry of Nuclear Reactor Systems. Bournemouth, U.K.
(The Secretariat, British Nuclear Energy Society at the Institution of Civil Engineers, 1 - 7 Great George Street, Westminster, London SW1P 3AA, U.K.)

CRYSTALLINE POLYMERS
October 13 - 17. Int. Symposium on Mechanical Properties of Crystalline Polymers. Massachusetts, U.S.A.
(Prof. E. E. Magat, Polymer Science and Engineering Department, University of Massachusetts, Amherst, Massachusetts 01003, U.S.A.)

SPECTROSCOPY
October 16 - 17 2nd World Spectroscopy Conference. Brussels, Belgium.
(Alena Enterprises of Canada (Alenca), P.O. Box 1779, Cornwall, Ontario, Canada K6H 5V7)

ENVIRONMENTAL POLLUTION
October 16 - 17 Int. Symposium on Environmental Pollution. Georgia, U.S.A.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, Canada K6H 5V7)

CLEAN AIR
October 20 - 26 5th Int. Clean Air Congress. Buenos Aires, Argentina.
(APCA Headquarters, P.O. Box 2861, Pittsburgh, Pennsylvania 15230, U.S.A.)

RADIATION PROCESSING
October 26 - 31 3rd Int. Meeting on Radiation Processing. Tokyo, Japan.
(Mr. Y. Orita, Secretary General, 3rd Int. Meeting on Radiation Processing, P.O. Box 6, Kurgangano, Takasaki, 370-12 Japan)

PROBLEMS OF MAN IN SPACE
November 3 - 6 6th Int. Symposium on Basic Environmental Problems of Man in Space. Bonn, Federal Republic of Germany.
(International Academy of Astronautics of the International Astronautical Federation, 250 Rue Saint-Jacques, F-75005 Paris, France)

MAN'S USE OF WATER
November 3 - 7 Int. Association on Water Pollution Research Conference on the Environmental Impact of Man's Use of Water. Brighton, U.K.
(Mr. G. Lee, Water Data Unit, Reading Bridge House, Reading RG1 8PS, U.K.)

NUCLEAR MEDICINE
November 3 - 7 2nd Asia and Oceania Congress of Nuclear Medicine. Manila, The Philippines.
(Dr. Flora M. Pascasio, P.O. Box EA 53, Ermita, Manila, The Philippines)

POLYMERS & PLASTICS
November 6 - 7 Int. Conference on Polymers & Plastics. New York, U.S.A.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, Canada K6H 5V7)

SOYA PROCESSING
November 9 - 14 World Conference on Soya Processing and Utilization. Acapulco, Mexico.
(American Oil Chemists' Society, 508 South Sixth St., Champaign, Illinois 61820, U.S.A.)

CLINICAL CHEMISTRY
November 11 - 15 1st African & Mediterranean Congress of Clinical Chemistry. Milan, Italy.
(1st African & Mediteranean Congress of Clinical Chemistry, Via Keplero 10, I-20124 Milan, Italy)

SPACE GEODESY
November 18 - 21 Int. Symposium on Space Geodesy and its Applications. Cannes, France.
(Centre National D'Études Spatiales, Département des Affaires Universitaires, 18 Avenue Édouard-Belin, F-31055 Toulouse Cédex, France)

REINFORCED PLASTICS
November 24 - 27 12th Int. Reinforced Plastics Congress: Markets for the 80's. Brighton, U.K.
(The British Plastics Federation, 5 Belgrave Square, London SW1, U.K.)

TECHNOLOGY FOR DEVELOPMENT
November 24 - 28 1st Int. Conference on Technology for Development. Canberra, Australia.
(I. E. Aust. 11, National Circuit, Barton, ACT 2600 Australia)

CHEMISTRY AND THE CITIZEN
December Asian and Pacific Chemical Conference on Interaction between Chemistry, Industry and the Citizen. Sri Lanka.
(Prof. S. Wijesundara, Vice Chancellor, University of Colombo, 94 Thurstan Road, Colombo 3, Sri Lanka)

NITROGEN FIXATION
December 1 - 5 4th Int. Symposium on Nitrogen Fixation. Canberra, Australia.
(Dr. A. H. Gibson, CSIRO Div. of Plant Industry, P.O. Box 1600, Canberra City, ACT 2601, Australia)

BIOCHEMISTRY - ASIA AND OCEANIA
December 14 - 18 Golden Jubilee of Society of Biological Chemists (India) and Second Congress of the Federation of Asian and Oceanic Biochemists. Bangalore, India.
(Mr. S. Krishnamurthy, Soc. of Biol. Chemists (India), Indian Institute of Science, Bangalore 560 012, India)

ALTERNATIVE ENERGY SOURCES
December 15 - 18 3rd Miami Int. Conference on Alternative Energy Sources. Miami Beach, Florida, U.S.A.
(Clean Energy Research Institute, University of Miami, P.O. Box 248294, Coral Gabels, Florida 33124, U.S.A.)

ENVIRONMENTAL POLLUTION
December 18 - 19 European Conference of Environmental Pollution. Frankfurt, Federal Republic of Germany.
(Vijay Mohan Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, Canada K6H 5V7)

1981

HEALTH IMPACTS OF ENERGY SOURCES
Int. Symposium on Comparative Health Impacts of Nuclear and Alternative Sources of Energy. U.S.A.
(Mr. Robert Najar, Conference Service Section, International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria)

ACID SULPHATE SOILS
January 12 - 17 2nd Int. Symposium on Acid Sulphate Soils, Bangkok, Thailand.
(S. Panichapongs, Secretary 2nd Int. Symposium on Acid Sulphate Soils, Department of Land Development, Bangken, Bangkok 9, Thailand)

FUTURE ENERGY CONCEPTS
January 27 - 29 3rd Int. Conference on Future Energy Concepts. London, U.K.
(Conference Dept., Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, U.K.)

TOXICOLOGY
March 4 - 7 Int. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142 - 144 Oxford Road, Cowley, Oxford OX4 2DZ, U.K.)

COLLOIDAL PARTICLE INTERACTIONS
March 16 - 21 Int. Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

ENERGY & ENVIRONMENT EDUCATION
March 26 - 31 Regional Seminar on Energy and Environment Education in Europe. Monte Carlo, Monaco.
(Ms Sheila Hopkinson, Conference Secretary, British Council, 10 Spring Gardens, London SW1, U.K.)

AMERICAN CHEMICAL SOCIETY
March 29 - April 3 181st National Meeting of the American Chemical Society. Atlanta, Georgia, U.S.A.
(Mr. A. T. Winstead, American Chemical Society, 1155—16th Street, NW, Washington, DC 20036, U.S.A.)

EURO BIOCHEMICAL SOCIETIES
March 29—April 4 14th Meeting of Federation of European Biochemical Societies. Edinburgh, Scotland.
(The Biochemical Society, 7 Warwick Court, London WC1R 5DP, U.K.)

ARID SOILS
March 29 - April 4 Int. Conference on Arid Soils. Jerusalem, Israel.
(D. H. Yaalon, Dept. of Geology, The Hebrew University of Jerusalem, Jerusalem 9100, Israel)

BIOTECHNOLOGY
April 5 - 10 2nd European Congress on Biotechnology. Eastbourne, U.K.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Sq., London SW1X 8PS, U.K.)

U.K. CHEMICAL CONGRESS
April 7 - 9 Chemical Society Annual Congress Guildford, U.K.
(Chemical Society, Burlington House, London W1V 0BN, U.K.)

METAL-HYDROGEN SYSTEMS
April 13 - 15 Int. Symposium on Metal Hydrogen Systems. Miami Beach, Florida, U.S.A.
(Dr. T. Nejat Veziroglu, Director of Clean Energy Research Institute, University of Miami, P.O. Box 248294, Coral Gables, Florida 33124, U.S.A.)

ELECTROANALYSIS
April 13 - 16 Int. Symposium on Electroanalysis in Clinical Environmental and Pharmaceutical Chemistry. Cardiff, Wales. U.K.
(Short Courses Section, Electroanalysis Symposium, UWIST, Cardiff, CF1 3NU, Wales, U.K.)

MÖSSBAUER EFFECT
April 13 - 17 Int. Conference on the Application of the Mössbauer Effect. Sringagar, Kashmir, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi - 110012, India)

CHEMISTRY/ASIA AND PACIFIC
April 26 - May 1 1st Asian & Pacific Chemistry Congress. Singapore.
(The Congress Secretary, 1st ISPAC Congress, Singapore Professional Centre, 129 B Block, Outram Park, Singapore 0316)

SCIENCE/PACIFIC REGION
May General Meeting of the Australian and New Zealand Association for the Advancement of Science. Brisbane, Australia.
(ANZAAS, 10, Martin Place, Sydney, 2000, Australia)

CLINICAL PHARMACOLOGY
May 11th Int. Symposium on Clinical Pharmacology. Pisa, Italy.
(Prof. Dr. A. Bertelli, via Roma 55, Pisa, Italy)

AGGLOMERATION
May 6 - 9 3rd. Int. Symposium on Agglomeration. Nürnberg, Federal Republic of Germany.
(NMA Nürnberger Messe- und Ausstellungsgesellschaft mbH, Messezentrum, D-8500 Nürnberg, Federal Republic of Germany)

TRACE ELEMENT METABOLISM
May 21 - 25 4th Int. Conference on the Trace Element Metabolism in Man and Animals. Perth, Australia.
(Australian Academy of Science, P.O. Box 783, Canberra City. ACT 2601, Australia)

HETEROGENEOUS & HOMOGENEOUS CATALYSIS
May 25 - 27 3rd Int. Symposium on Relations between Heterogeneous and Homogeneous Catalysis. Groningen, Netherlands.
(Dr. R. S. Downing, Koninklijke/Shell-Laboratorium, Postbus 3003, NL-1003 AA Amsterdam, Netherlands)

ACTIVATION ANALYSIS
May 31 - June 4 6th Int. Conference on Modern Trends in Activation Analysis. Toronto, Ontario, Canada.
(Dr. R. E. Jervis, 6th MTAA Conference Convenor, Faculty of Applied Science and Engineering, University of Toronto, Ontario, Canada M5S 1A4)

FREE RADICALS
June 15th Int. Symposium on Free Radicals. Canada.
(Prof. W. E. Jones, Dept. of Chemistry, Dalhousie University, Halifax, Nova Scotia B3H 4T3, Canada)

ORGANIC CHEMISTRY
June 1 - 5 2nd. European Symposium on Organic Chemistry, Stresa, Italy.
(Prof. Giorgio Modena, Istituto di Chimica Organica, Via Marzolo 1, Italy - 35 100 Padova)

RUBBER CONFERENCE AND EXHIBITION
June 8 - 12 1981 Int. Rubber Conference and Exhibition. Harrogate, U.K.
(RUBBERCON'81, Richard H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, U.K.)

WOOD AND PULPING
June 9 - 12 The "Ekman-days" Int. Symposium on Wood and Pulping Chemistry. Stockholm, Sweden.
(Dr. P. F. Nelson, Australian Paper Manufactures Ltd., Research Laboratory, 17 Rex Ave., Alphington, Victoria 3078, Australia)

SURFACE AND COLLOID SCIENCE
July 5 - 10 4th Int. Conference on Surface and Colloid Science. Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Jerusalem, Israel)

MACROMOLECULAR CHEMISTRY
July 6 - 9 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, 1er Etage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cédex 05, France)

CONFERENCES 1981

DETERMINATION OF POLYMER STRUCTURE
July 20 - 23 22nd Prague Microsymposium on Characterization of Dynamic & Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Science, Heyrovského N.2, CS-16206 Praha 616, Czechoslovakia)

NMR
July 12 - 17 5th Int. Meeting on NMR Spectroscopy. Exeter, U.K.
(U.K. Chemical Society, Burlington House, London W1V 0BN, U.K.)

POLYMER CHARACTERIZATION
July 13 - 17 Int. Symposium on Advances in Polymer Characterization. Durham, U.K.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE U.K.)

NON-CONVENTIONAL ENERGY SOURCES
July 14 - Aug. 6 2nd International Symposium on Non-conventional Energy. Topics include solar energy fundamentals, advanced solar energy technology, bioconversion, materials science for solar energy conversion and management of energy. Miramare-Trieste, Italy.
(International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste, Italy)

CHEMOTHERAPY
July 19 - 24 12th Int. Congress of Chemotherapy. Florence, Italy.
(Prof. Dr. P. Periti, Viale Morgagni 65, 1-50134 Florence, Italy)

PLATINIUM GROUP METALS
July 19 - 24 Int. Conference on the Chemistry of Platinium Group Metals. Bristol, U.K.
(Dr. P. L. Gogin, School of Chemistry, The University, Bristol BS8 1TS, U.K.)

PHARMACOLOGY
July 19 - 24 8th Congress of the Int. Union of Pharmacology. Tokyo, Japan.
(Dr. F. Gross, Dept. of Pharmacology, University of Heidelberg, Im Neuenheimer Feld 366, D-6900 Heidelberg, Federal Republic of Germany)

ORGANIC SYNTHESIS
July 20 - 23 7th Int. Symposium on Synthesis in Organic Chemistry. Oxford, U.K.
(U.K. Chemical Society, Burlington House, London W1V 0BN, U.K.)

CAROTENOIDS
July 26 - 31 6th Int. Symposium on Carotenoids. Liverpool, U.K.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, U.K.)

ORGANOMETALLIC CHEMISTRY
August 2 - 6 Int. Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, Colorado, U.S.A.
(Prof. J. K. Stille, Dept. of Chemistry, Colorado State University, Fort Collins, Colorado 80523, U.S.A.

ORGANOMETALLIC CHEMISTRY
August 9 - 14 10th Int. Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

CHEMICAL EDUCATION
August 9 - 14 6th Int. Conference on Chemical Education Maryland, U.S.A.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, U.S.A.)

IUPAC CONGRESS
August 16-22 28th IUPAC Congress. Vancouver, Canada.
(Mr. T. H. G. Michael, Executive Director, The Chemical Institute of Canada, 151 Slater St., Ottawa, Ontario KIP 5H3, Canada)

CRYSTALLOGRAPHY.
August 16 - 25 12th Int. Congress of Crystallography. Ottawa, Canada.
(Mr. K. Charbonneau, Executive Secretary, 12th IUCr Congress, National Research Council of Canada, Ottawa, Ontario, Canada KIA OR6)

ATMOSPHERIC PHYSICS
August 16 - 29 Int. Association of Meterology and Atmospheric Physics. Hamburg, Federal Republic of Germany.
(Mr. Stanley Ruttenberg, Secretary General IAMAP, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307, U.S.A.)

ANALYTICAL STUDIES
August 20 - 21 Int. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford St., London SE1 9NQ, U.K.)

AMERICAN CHEMICAL SOCIETY
August 23 - 28 ACS Fall Meeting. New York City, U.S.A.
(American Chemical Society, 1155 16th Street, NW, Washington DC 20036, U.S.A.)

GOLDEN JUBILEE
August 23 - 28 Golden Jubilee Conference. Auckland, New Zealand.
(Dr. D. J. McLennan, Chemistry Dept., University of Auckland, Auckland, New Zealand)

EUROANALYSIS
August 23 - 28 4th FECS Euroanalysis Conference. Helsinki, Finland.
(Euroanalysis-IV, Association of Finnish Chemical Societies, Mr. Veikko Velamo, Executive Director, Pohj. Hesperiankatu 3 B 10, SF-00260 Helsinki 26, Finland)

BIOPHYSICS
August 23 - 29 7th Int. Biophysics Congress and 3rd Panamerican Biochemistry Congress. Mexico City.
(Dr. Hugo Arechiga, Cerrada de Popocatepetl 51-A, Colonia General Anaya, Mexico 13, D.F., Mexico)

SOLAR ENERGY
August 24 - 28 Int. Solar Energy Congress. Brighton, U.K.
(Prof. David Hall, University of London, Kings College, 69 Half Moon Lane, London SE24 9JF, U.K.)

DRUG RESEARCH
August 25 - 28 2nd IUPAC-IUPHAR Symposium on Strategy in Drug Research. Noordwijkerhout, Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B.V., P.O. Box 2, NL-1380 AA Weesp, Netherlands)

HISTORY OF SCIENCE
Aug. 26 - Sept. 3 16th Int. Congress of the History of Science. Bucharest, Romania.
(S. Balan, Romanian Academy of Science, Calea Victoriei 125, Set 1, Bucharest, Romania)

AROMATIC COMPOUNDS
Aug. 30 - Sept. 4 4th Int. Symposium on Chemistry of Novel Aromatic Compounds. Jerusalem, Israel.
(Prof. I. Agranat, Department of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

CLINICAL CHEMISTRY
Aug. 30 - Sept. 5 11th Int. Congress of Clinical Chemistry. Vienna, Austria.
(Secretariat, 11th Int. Congress of Clinical Chemistry, 4th European Congress of Clinical Chemistry, P.O. Box 35, A-1095 Wien, Austria)

FERMENTATION TECHNOLOGY
Aug. 31st - Sept. 3rd 3rd. Int. Conference on Computer Applications in Fermentation Technology. Manchester, U.K.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Square, London SW1X 8PS, U.K.)

PHOTOCHEMISTRY
September 10th Int. Conference on Photochemistry. Crete, Greece.
(Dr. P. M. Rentzepis, Bell Laboratories, ID 358, Murray Hill, New Jersey 07974, U.S.A.)

CONFERENCES 1981/82

THE ROLE OF FOOD SCIENCE
September Symposium on The Role of Food Science in the Community (Int. Union of Food Science & Technology). Helsinki, Finland.
(Prof. P. Koivistoinen, Institute of Food Chemistry and Technology, Helsinki, Finland)

CHROMATOGRAPHY
September 1 - 4 3rd Danube Symposium on Chromatography, c/o Hungarian Chemical Society, P.O. Box 240, H-1368 Budapest, Hungary)

METALLIC CORROSION (ICMC)
September 6 - 11 8th Int. Congress on Metallic Corrosion (ICMC). Mainz, Federal Republic of Germany.
(DECHEMA, 8th ICMC, Postfach 97 01 46, D-6000 Frankfurt/Main 97, Federal Republic of Germany)

PHOTOCHEMISTRY
September 6 - 12 10th Int. Conference on Photochemistry. Iraklion, Crete, Greece.
(P. M. Rentzepis, Bell Laboratories ID, 358 Murray Hill, NJ 07974 U.S.A.)

ANAEROBIC DIGESTION
September 6 - 12 2nd Int. Symposium on Anaerobic Digestion. Travemunde, Federal Republic of Germany.
(2nd International Symposium on Anaerobic Digestion, 142 - 144 Oxford Road, Cowley, Oxford, U.K.)

RADIOPHARMACOLOGY
September 9 - 11 2nd Int. Symposium on Radiopharmacology, Chicago, Illinois, U.S.A.
(Pharmacology Department, School of Medicine, Loyola University, Maywood, Illinois 60653, U.S.A.)

CHEMICAL PHYSICS
October 1 - 7 Int. Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of U.S.S.R. Vorobyevskoye Chaussee 2-b, SU-117334 Moscow, U.S.S.R.)

CHEMICAL ENGINEERING
October 4 - 9 Interamerican Congress of Chemical Engineering. Montreal, Canada.
(Canadian Society for Chemical Engineering, 151 Slater St., Suite 906, Ottawa, Ontario, Canada K1P 5H3)

WATER POLLUTION CONTROL
October 4 - 10 Water Pollution Control Federation Int. Convention. Detroit, Michigan, U.S.A.
(R. A. Canham, 3900 Wisconsin Avenue, NW, Washington DC 20016, U.S.A.)

ENVIRONMENTAL POLLUTION
December 18 - 19 European Conference on Environmental Pollution. Frankfurt, Federal Republic of Germany.
(Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario, K6H 5V7 Canada)

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CHEMISTRY RELATING TO AGRICULTURE
February 2 - 5 Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN II) Manila, Phillipines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington, DC 20036, U.S.A.)

SAFE USE OF SOLVENTS
March 23 - 27 Int. Symposium on the Safe Use of Solvents. Brighton, U.K.
(Mr. S. G. Luxon, Health & Safety Executive, 25 Chapel Street, London NW1 4DT, U.K.)

U.K. CHEMICAL CONGRESS
March 30 - April 1 Annual Chemical Congress.
(Chemical Society, Burlington House, London W1V 0BN, U.K.)

SOLUTE—SOLVENT INTERACTIONS
July 5 - 10 6th Int. Smyposium on Solute-Solute-Solvent Interactions. Osaka, Japan.
(Prof. H. Otaki, Tokyo Institute of Botany, Faculty of Science, University of Tokyo, 7-3-1- Hongo, Bunkyo-ku, Tokyo 113, Japan)

PHYSICAL ORGANIC CHEMISTRY
July 11 - 16 6th IUPAC Conference on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholique de Louvain, Laboratoire de Chimie Générale et Organique, Bâtiment Lavoisier, 1 Place Louis Pasteur, B-1348 Louvain-la-Neuve, Belgium)

MACROMOLECULES
July 12 - 16 IUPAC Macromolecular Symposium. Amherst, Massachusetts, U.S.A.
(James C. W. Chien, Dept. of Polymer Science and Engineering, University of Massachussetts, Amherst, Massachusetts 01003, U.S.A.)

NATURAL PRODUCTS
August 2 - 7 13th Int. Symposium on Chemistry of Natural Products. Pretoria, South Africa.
(Mrs Jeanne Beck, National Chemical Research Laboratory, CSIR, P.O. Box 395, Pretoria 0001, South Africa)

BIOCHEMISTRY
August 15 - 21 12th Int. Congress of Biochemistry. Perth, Australia.
(Prof. B. N. Preston, Biochemistry Dept. Monash University, Clayton, Victoria 3168, Australia)

ORGANIC SYNTHESIS
August 22 - 27 4th Int. Conference on Organic Synthesis. Tokyo, Japan.
(Prof. T. Mukaiyama, Dept. of Chemistry, Faculty of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan)

COORDINATION CHEMISTRY
August 23 - 27 22nd Int. Conference on Coordination Chemistry. Budapest, Hungary.
(Prof. M. T. Beck, Institute of Physical Chemistry, Kossuth Lajos University, Debrecen 10, H-4010 Hungary)

PESTICIDE CHEMISTRY
Aug. 29 - Sept. 4 5th Int. Congress of Pesticide Chemistry. Kyoto, Japan.
(Rikagaku Kenkyusho (The Institute of Physical and Chemical Research), 2 - 1 Hirosawa Wako-shi Saitama Pref 351, Japan)

POLYMERIZATION OF HETEROCYCLES
Summer Int. Symposium on Polymerization of Small Heterocycles. Poland.
(Prof. Z. Jedliński, Polish Academy of Sciences, Polymer Institute, P.O. Box 49, Curie - Sktodowskiej 34, PL-41 800 Zabrze, Poland)

MYCOTOXINS AND PHYCOTOXINS
Aug. 31 - Sept. 2 5th Int. Symposium (IUPAC) on Mycotoxins and Phycotoxins. Vienna, Austria.
(Prof. Palle Krogh, Department of Microbiology, Royal Dental College, Juliane Mariesvej 302, DK-2100 Copenhagen Ø, Denmark)

CHEMICAL STRUCTURE—BIOLOGICAL ACTIVITY
September 6 - 9 4th European Symposium on Chemical Structure and Biological Activity: Quantitative Approaches. Bath, U.K.
(Dr. J. C. Dearden, School of Pharmacy, Liverpool Polytechnic, Byrom St., Liverpool L3 3AF, U.K.)

PREPARATION OF HETEROGENEOUS CATALYSTS
September 6 - 9 3rd. Int. Symposium on the Scientific Bases for the Preparation of Heterogeneous Catalysts. Louvain-La-Neuve, Belgium.
(Prof. B. Delmon, Université Catholique de Louvain, Groupe de Physico-Chimie Minérale et de Catalyse, Place Croix du Sud 1, B-1348 Louvain-La-Neuve, Belgium)

WATER POLLUTION
October Water Pollution Control Federation Int. Convention. Saint Louis, Missouri, U.S.A.
(R. A. Canham, 3900 Wisconsin Avenue NW, Washington DC 20016, U.S.A.)

Chemistry International

is the news magazine of the

INTERNATIONAL UNION of PURE and APPLIED CHEMISTRY (IUPAC)

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

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Israel Academy of Sciences and Humanities **(Israel)**
Consiglio Nazionale delle Ricerche **(Italy)**
Science Council of Japan **(Japan)**
Koninklijke Nederlandse Chemische Vereniging **(Netherlands)**
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Norsk Kjemisk Selskap **(Norway)**
Polska Akademia Nauk **(Poland)**
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Unija Hemijskih Društava Jugoslavije **(Yugoslavia)**

Chemistry International

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Pilot programmes attempt to bridge the industry-university chemistry chasm

Among chemists, the main factor causing poor communication and misunderstanding does not appear to be language, race or culture. Rather, there appears to be a nearly universal tendency for chemists within most countries to become polarized into two isolated camps: university and industrial chemistry. Their goals are often viewed as divergent. Industrial chemists are concerned with developing or maintaining commercial processes for making chemical products. University chemists perform research for which applied, practical results are usually not expected, and often not even sought. University education, it is often charged, is not geared to the needs of industry. Industry, it is claimed, is hesitant to undertake long-term research programmes and is little concerned with pollution or conserving resources.

The need to open avenues of communication is becoming widely recognized and discussed, and pilot projects are being started in many countries. These programmes may involve industrial chemists presenting lectures at universities, university faculty and students studying technical problems faced by small chemical industries, plant tours for students to see industrial applications of course material, and sharing of specialized equipment and facilities.

One of the most important ways to prepare students for practical work outside the university environment is through joint university - industry work - study programmes. Cooperative education programmes have been operating for more than 70 years, and in recent years, there has been a marked growth in the number of students participating in these programmes, especially among engineering students. In chemistry, however, there are relatively few cooperative programmes and only a handful of these involve an appreciable number of students.

This could be starting to change. In the United States, the American Chemical Society has recently established an Office of Cooperative Education. Robert Ridgway, Manager of the new ACS Office, reported to *Chemistry International* that "The ACS Office of Cooperative Education is, as far as I know, novel in that it promotes cooperative education for all members of the chemical profession: students, employers and schools." During its first year of operation, the Office plans to establish a clearinghouse to aid in the placement of chemistry "co-op" students, present regional conferences for industrial and academic institutions interested in starting cooperative education programmes, gather and disseminate information dealing with cooperative programmes, and help establish five new programmes to serve as a development model for joint industry-academic education.

For over thirty years, the International Association for the Exchange of Students for Technical Experience (IAESTE) has coordinated the exchange of undergraduate and graduate students for work experience abroad. Students are provided with work related to their university studies, usually during their 8-12 week university summer holiday, although work periods up to a year may be arranged. Employment offers are generally made by industrial companies or research institutes to IAESTE national committees in 48 member countries. The committees, consisting of representatives from industry and university, exchange employment offers on a reciprocal basis. Each committee then selects qualified students from applicants in affiliated universities and colleges. During 1979, 234 chemistry and 16 biochemistry students were provided with work experience in this way, reports Mr. G. Anemoyannis, General Secretary of IAESTE (P.O. Box 3414, Kolonaki Post Office, Athens, Greece). This, however, represents only a small fraction of the nearly 5000 students placed in work abroad among all scientific, engineering and technical fields.

Experience with cooperative education (mostly in subjects other than chemistry) indicates that it is beneficial to students, employers and to university-industry relations. Students often feel that their academic training has greater meaning when they see its practical applications: employers find cooperative education an excellent recruitment tool (many students go on to full-time positions with the same company after graduation); and the students bring their industrial experience back into the classroom. The only clear disadvantage is that it generally extends the time required for students to complete their undergraduate degree by 3 months—1 year.

Most joint university-industry education programmes involve full-time industrial work for

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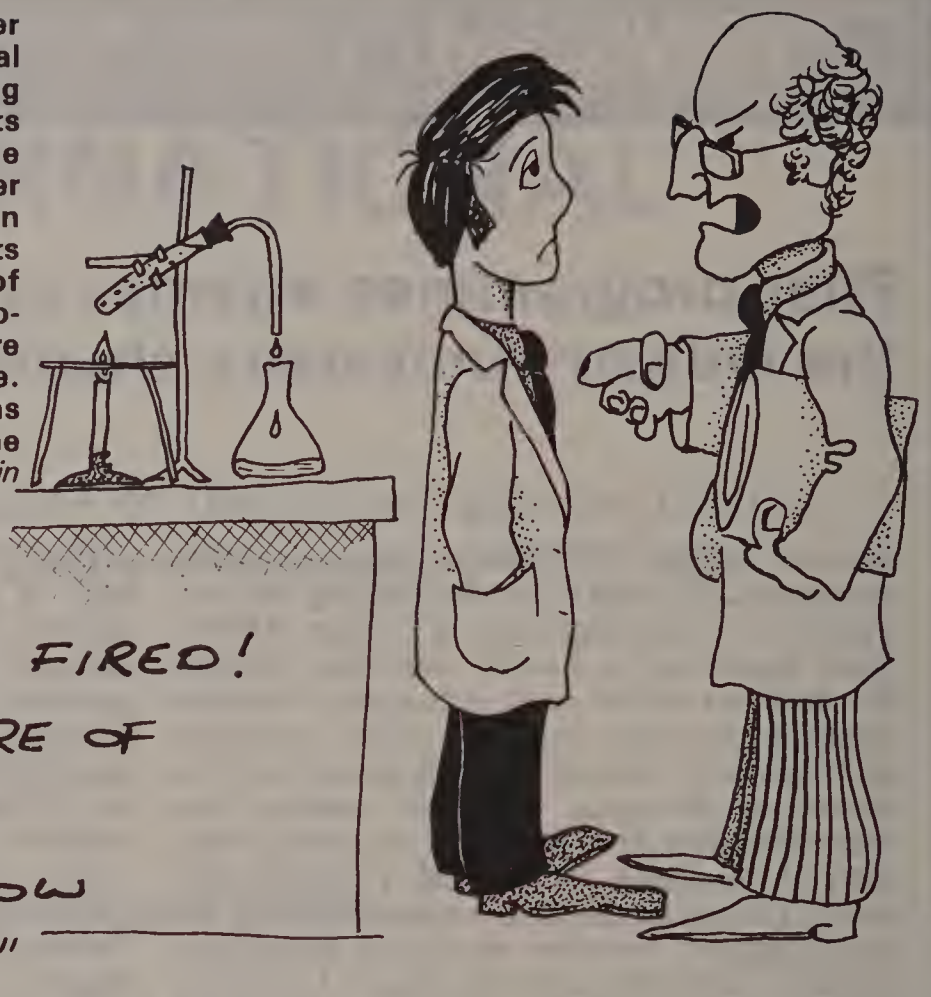
University training is given greater meaning when students see practical industrial applications. By participating in work-study programmes, students also take their industrial experience back into the classroom. But in order for joint university - industrial education programmes to be successful, students should be placed under supervision of an individual who recognizes that co-operative work - study programmes are primarily an educational experience. The supervisor should see his role as "teacher", as well as supervisor in the normal sense (*adapted from a cartoon in the Co-op Digest by Phil Frank*).



the student during alternate semesters. For cases where the industrial site is situated near the university, it is convenient to arrange "parallel" cooperative programmes, with classes and work periods each occupying part of the day.

In order for joint university - industry education programmes to be successful, they must be carefully considered and planned by the university and the industrial organization. Advice is available from the Cooperative Education Research Center (401 Stearns Center, Northeastern University, 360 Huntington Avenue, Boston MA 02115, USA). Among the suggestions provided in their brochure "Guidelines for employers considering the use of a co-operative education program" is that employers should recognize first and foremost that cooperative education is an *educational* programme integrated with practical experience, requiring proper utilization of students. Students should be placed under supervision of an individual who sees his role as "teacher", as well as supervisor in the normal sense. A well-qualified employer coordinator, who understands and supports the objectives of cooperative education, should monitor the employee student's progress. Furthermore, they recommend that student employees are always provided with work to do, that work assignments should progress from more routine activities early in the programme to more complicated responsibilities, and that students are paid a fair salary for the work that they do.

The recent involvement in joint university-industry education programmes by the American Chemical Society (and also the Science Research Foundation in the UK) does not mean that the need is most acute in these countries. If anything, academic and industrial chemists appear to be even more isolated in smaller countries. "While it is not uncommon for British and USA university research departments to have industrial support for research students . . ." reports the Royal Australian Chemical Institute (RACI) publication *Chemistry in Australia* (March 1980, p. 84 -86), "this type of support is almost entirely absent (in Australia) due to the small size of the industrial R&D effort . . ." It continues, "The concept that the PhD student could carry out part of his research in a university and another part in an industrial laboratory is quite foreign to the Australian scene." The thrust of the article is carried poignantly by its opening statement, "The RACI believes that the present level of interaction between Government, Academic and Industrial Research activities in Australia is totally inadequate. . ."

The *Chemistry in Australia* article makes several specific recommendations to enhance employee mobility between the three sectors of the chemical profession. Chemists would be more willing to change work assignments, the authors believe, if they could transfer benefits accrued through seniority (including retirement and sick leave entitlement). This is singled out as a major long-term objective for government change and funding. The Royal Australian Chemical Institute also recommends that Australian industry might make greater use of academic and government consultants, and that government funding be provided for visiting consultants or research fellows to spend up to

three months establishing joint research programmes. In order to promote such activities, the article suggests that a directory be compiled of scientists willing to act as consultants in their area of expertise, that a list of university laboratories interested in joint programmes be assembled, and that CSIRO (the scientific research organization of the Australian government) and Australian industry compile a list of chemical problems which need solving—to which academic chemists might devote their attention.

Such a directory might encourage university faculty and industrial chemists to take the first step towards establishing contacts across the university - industry gap. One High School chemistry teacher (Stephen Coombes, writing in *Education in Chemistry,* May 1980), reports how frustrating and time-consuming this can be. While teaching the principles of filtration to his class, he thought that a tour of the nearby water treatment plant would provide a meaningful, practical illustration of the concepts. The enthusiasm generated amongst his students was ultimately to exceed his expectations, but Mr. Coombs nearly abandoned the idea before he could contact the appropriate individual at the water pollution control works—situated just across the field from the school.

This experience showed, or seemed to show, that much time could be saved if teachers shared their experiences and contacts with local industry. A circular letter was sent to all secondary schools within the district, but the replies revealed that practically none of the teachers had made any contacts, and that the anticipated "pool of experience" simply did not exist. However, as a result of these efforts, a small group of teachers became sufficiently interested to prepare a "chemistry teacher's resource directory" for the education district centred at Leeds (in the UK).

The problem of university - industry isolation might be pursued not only on a local or national level, but within geographical regions encompassing several countries. The establishment of a *Regional Liaison Centre* for this purpose was recommended by an Asian Working Party with participants from China, India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore and Thailand. Their conclusions, formulated during their October 1979 meeting in the Philippines (reported in the newly re-entitled Newsletter *Chemistry in Asia*), stress that universities should take the initiative in promoting university - industry interactions. Especially in developing nations, they assert, universities should recognize the value of applied, mission-oriented research. They urge universities to recognize sabbaticals of university faculty spent in industry, and to offer "visiting professor" or similar academic status to industry scientists interested in lecturing or research at universities. Until a Liaison Centre is established in Asia, information about university - industrial contacts will be channelled by Dr. Modesto Chua, Director of the Philippine Institute of Pure & Applied Chemistry, Atteneo de Manila University, Loyola Heights, Quezon City, the Philippines. It is expected that an Asian Liaison Centre will eventually serve as regional coordinator for interaction activities, collecting and disseminating news and "success stories".

Success stories *are* reported, although so far, relatively few in chemistry. An interesting example is the Chemical Engineering Programme at the University of Canterbury (New Zealand). There, all chemical engineering students are required to spend three summer recesses solving practical industry problems. Because the scale of the programme outstrips the availability of appropriate supervised projects in large well-staffed industries (in nearby paper mills and oil refinery), the University works with smaller chemical process industries such as fertilizer plants and electroplating works. The small companies in these industries are frequently unable to allocate staff time and resources for in-house research and development, even for basic technology involved in production and analytical testing.

With many of these small companies, university staff and industrial supervisors are able to identify problems suitable for student research. Afterwards, university staff members supervise students at the plant site until the project is established. Company technical staff provide additional advice and assistance to the students. In this way, the company benefits from a student worker and a part-time academic consultant. Upon completion of the project, the company is free to accept or reject the recommendations made. In one case, a modification to a sulphuric acid plant could be implemented at only a few hundred dollars cost, reducing electrical power consumption and saving NZ$10,000/year!

Joint programme prepares oilsands specialists

Combining industrial experience with related coursework, the new oilsands engineering programme at the University of Alberta (Canada) is aimed at producing Masters-level graduates for this rapidly-developing area of energy research and development. According to *Chemistry in Canada* (June 1980 issue), students will spend 8 months of the two-year program taking courses dealing with advanced heat transfer, flow through porous media, environmental engineering, and *in situ* recovery. During the remaining 16 months, the students will work on projects sponsored by the Alberta Oil Sands Technology & Research Authority, receiving salaries typical of those in the industry.

In an article explaining the programme in the April issue of *Chemistry in New Zealand,* Prof. A. G. Williamson states that "although the procedure . . . is presently used in a chemical engineering degree, I see no reason why it should not be applied to chemistry degree courses." Furthermore, he adds later that "many of those (projects) I have supervised would be within the capability of a good final year honours chemistry student, and quite a number are mainly chemical in nature."

The extent of staff interchange between universities and industry varies greatly from country to country, as was readily apparent from presentations made at a UNESCO-sponsored European Regional Seminar on University - Industry Interactions (held in Lisbon on 3 - 7 December 1979). While seminar speakers reported that little or no staff interchanges occur in Italy, a speaker from the German Democratic Republic explained that in his country great importance is attached to systematic exchange of scientists from various institutions. In the East German republic, experts from industry teach at universities as visiting or honorary professors. A similar situation was reported in the USSR, where it is obligatory for professors and their assistants to work for three months in industry or a research centre once every five years. Specialists from Soviet industry are also widely involved with teaching at institutes of higher education. In the Netherlands, senior researchers from industry act as part-time professors or senior lecturers, but the interaction is one-sided: university staff members rarely enter industry.

By the end of the seminar, there was clear agreement among the participants on several key points. They concluded that university - industry interactions are vital to the future development of both sectors, and that government funding was necessary to promote these interactions in chemistry. The establishment of national bodies to coordinate future programmes was seen as a necessary stage in the expansion of joint university - industrial projects. In order to open university - industry channels of communication where they are now inadequate or non-existent, chemical societies and academies of science could perform an important role.

But perhaps even more significant than these conclusions was the unanimous agreement that the development of *personal contacts* is a critical factor in promoting university - industry interactions. Problems are certain to arise in any programme involving exchanges of staff, sharing of equipment and access to specialist facilities. Resolving these difficulties will depend very much on personal contact, friendship and the good will of the participants.

Student research projects aid local industry

Research conducted in an industrial environment comprises an essential part of chemical engineering education at the University of Canterbury in New Zealand. Close association of university staff with local industry in supervising student research has led to further university - industry interactions. Faculty members sometimes serve as industrial consultants, and academic research projects have developed as an offshoot of studying specific industrial problems. Many of the projects have required chemical studies, as well as engineering. Two examples:

Sodium bisulfite is used as a reducing bleach and for controlling acidity in the treatment of wool. In order to develop a local source of the compound, university students examined the feasibility of producing $NaHSO_3$ as a byproduct of sulfuric acid manufacture. Sodium bisulfite can be produced by the reaction

$$2SO_2 + Na_2CO_3 + H_2O \longrightarrow 2NaHSO_3 + CO_2$$

Because of the unusual physical chemistry involved in the reaction, reaction conditions must be closely controlled. Instead of the desired product, $NaHCO_3$ can precipitate when SO_2 is bubbled into the Na_2CO_3 solution if it is saturated. A study of the reaction chemistry yielded the design data and operating conditions for a small plant. The plant has now been built and commissioned by students and supplies bisulfite solution to several local wool treatment plants. Further studies are underway to investigate modification of the pilot plant for the production of sodium sulfite.

Phosphate rock contains small quantities of fluoride. When it is treated with acid in fertilizer plants, volatile HF and SiF_4 are evolved. These gases dissolve in the scrubbing water used to remove airborne phosphate dust, producing a dilute fluoride waste solution. In order to utilize this fluoride, it was suggested that the scrub water might be recycled - thereby raising the fluoride concentration to the point where it could be sold as an additive to municipal water supplies.

A student project was initiated to investigate this possibility. Although the study demonstrated that a suitable fluoride solution could be produced without loss of scrubbing efficiency, the process was considered uneconomic and was not implemented. Nonetheless, the study indicated that it might be feasible to convert the H_2SiF_6 content of the scrubbing solution to AlF_3 flux (for use in an aluminum smelter). A further study is now underway to examine this process.

Electrochemical propulsion promises fuel efficient transportation

In order to survive increasingly stringent pressures for fuel conservation, automobile manufacturers are exploring radical new chemical and electrochemical propulsion systems. In the short-term, fuel consumption will likely be reduced by engineering modifications to the internal combustion engine and expanding usage of lightweight polymers and metal alloys in automobile bodies. On a long-term basis, however, fundamental changes are likely to be introduced in the way in which automobiles are propelled. By the turn of the century, automobiles will likely be very different from present vehicles, whose basic design evolved during an era of cheap and plentiful hydrocarbon fuels.

One area where important technological advances are expected is in the development of new electrochemical batteries able to store large amounts of electrical energy. Mobile battery systems would obtain electrical energy from large electric generating stations powered by coal or nuclear power. These centralized facilities would be able to convert combustion or nuclear heat to electric power with about 35% efficiency, while maintaining strict control on pollution emissions. Batteries on-board each automobile would store this electrical energy and release it on demand to produce mechanical power in an electric motor. Overall, fuel energy might be converted to mechanical power with about 20 - 25% efficiency. In contrast, a conventional petrol engine is only about 15% efficient.

Undermining the potentially high fuel efficiency of electric vehicles is the weight of present-day battery systems. With conventional battery technology, marginally-acceptable performance can be achieved only when the battery is the largest and heaviest component of the vehicle. A substantial fraction of the energy stored by the battery must then be expended in transporting its own weight. Thus, at present, electric vehicles are not believed to be more energy efficient than petrol-powered vehicles, except in congested city centre driving or specialized applications (urban delivery vans).

The low fuel consumption that should ultimately be possible with electric propulsion will be realized only if efficient and lightweight batteries, battery chargers, drive systems and controllers are developed. The advantage that ultimately is to be achieved depends very much upon future technological advances.

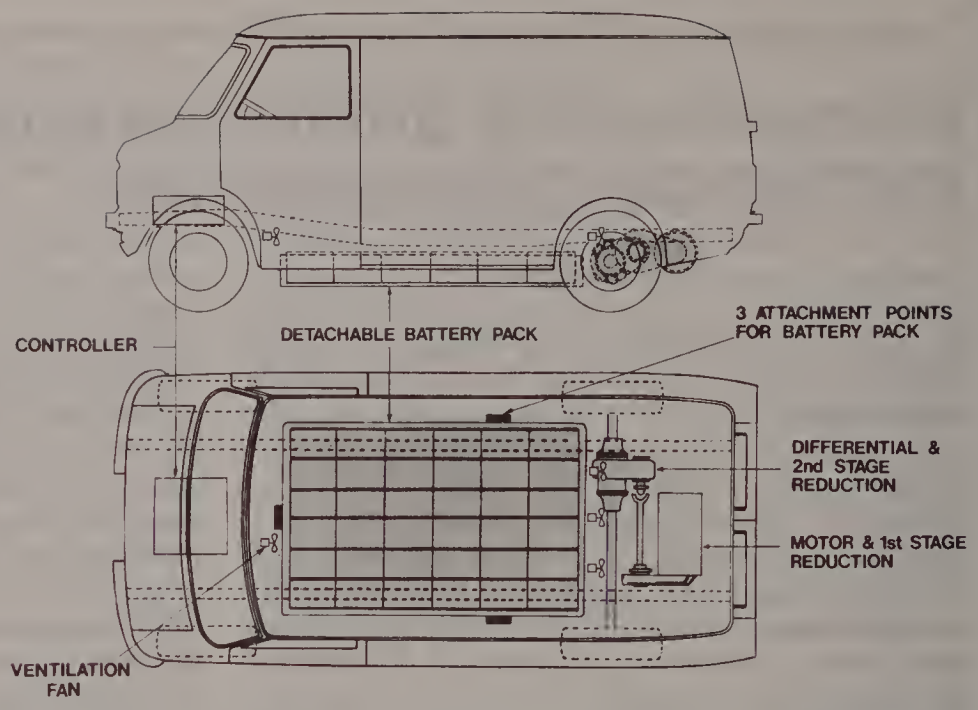
But technical improvements will *not* be the major factor responsible for the developing advantage of electric vehicles: advances in electric propulsion will likely be matched by design improvements in the internal combustion engine. The breakthrough will come when coal is utilized to provide energy (liquid fuel or electricity) for motor transport. Electric vehicles will be able to utilize this resource more efficiently than will conventional vehicles powered by coal-derived liquid fuel. This latent superiority of the electric vehicle, expected to emerge in the 1990's, is pointed out in the paper *A review of the energy case for electric vehicles* (presented at the 3rd International Conference of the Electric Vehicle Development Group, November 1979). The authors, Drs. Peter McGeehin and Ronald Dell, project that hydrocarbon fuels made by coal liquefaction will retain only 55 -60% the input energy of the coal feed. Instead of producing synthetic liquid fuels, a much more efficient alternative would be to burn coal and generate electricity for vehicle propulsion.

Besides reduced energy consumption, the powering of automobiles by electricity offers very attractive features: nearly silent, vibration-free operation, no emission of vehicle pollution in congested city centres, simple mechanical components and long vehicle service life. These features have long been recognized, but for nearly 100 years, the lead - acid battery has been the only practical electrochemical energy storage device for electric vehicles. Its limited energy storage capacity severely restricted the range, speed and performance of electric vehicles.

That is almost certain to change as a new generation of advanced battery systems are perfected. Significant efforts are being directed worldwide to the development of efficient batteries of high energy density. An increase in the attainable energy storage density is of crucial importance in achieving an acceptable range (perhaps 150 km on one battery charge) and speed in electric vehicles.

Some of the new battery systems, such as Zn/NiOOH, Fe/NiOOH and advanced versions of the Pb/PbO_2 lead - acid battery use water-based electrolytes. Chief among the non-aqueous electrochemical batteries are the Li-Al/Fe S_x cell with a molten salt electrolyte and the NaS battery with a ceramic conductor. These require good heat insulation to maintain the high temperatures at which they operate. Less well recognized, perhaps, are the metal-air (zinc/air, aluminium/air and lithium/air and metal halogen batteries. These include the zinc-chlorine, and more recently, the zinc-bromine electrochemical cells.

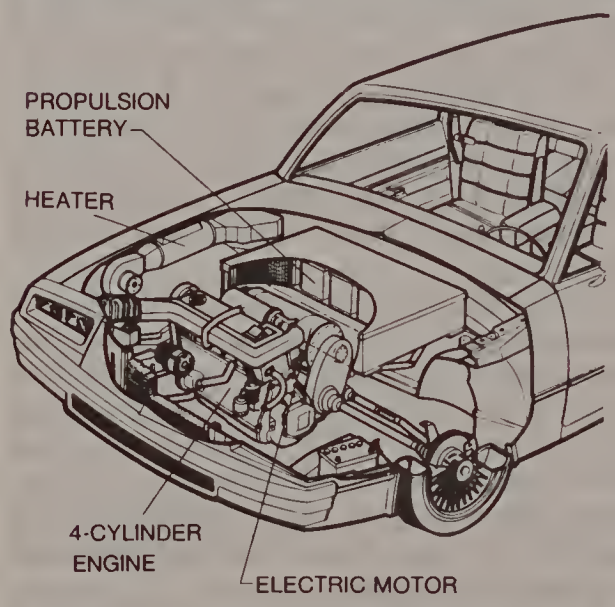
Each of these battery systems offer potential advantages, but all promise enhanced energy storage density. They are based on electro-

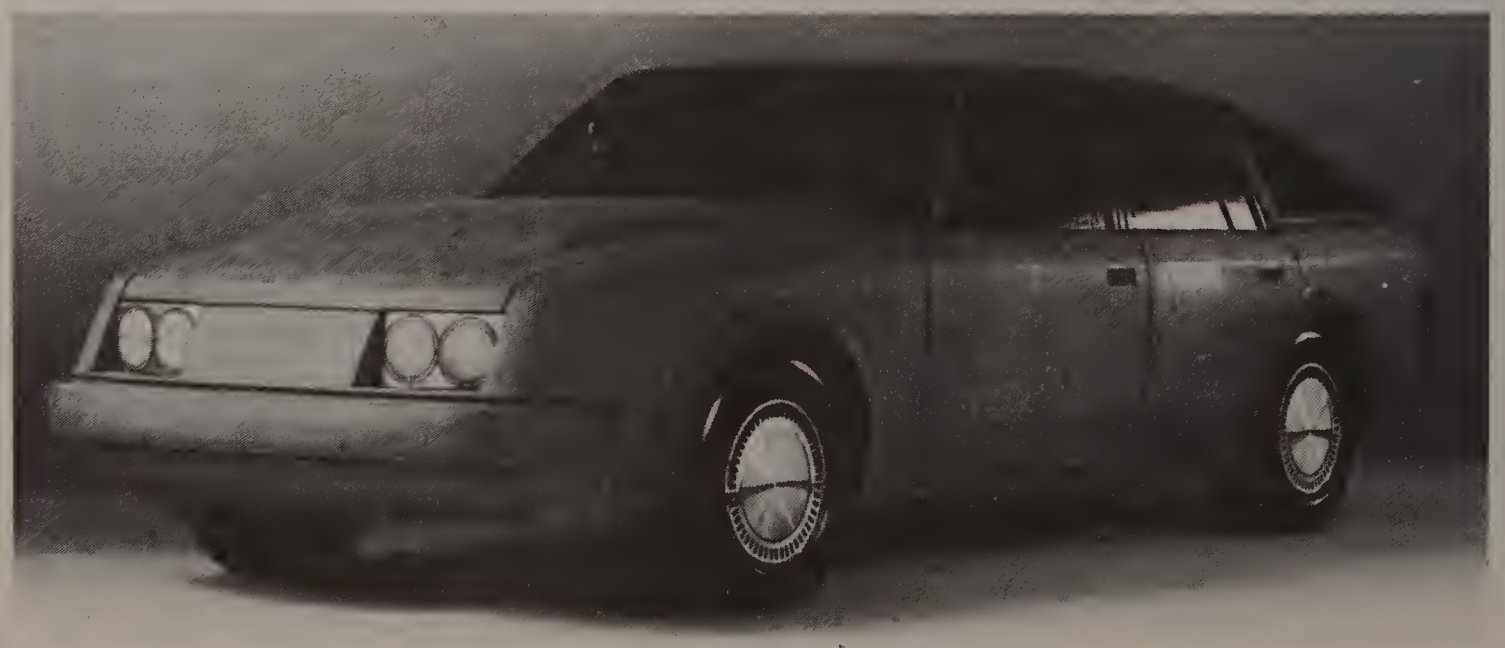


Until second generation battery systems are fully developed, maufacturers are relying on lead-acid batteries to get their electric vehicle designs off the drawing board, and onto the road. The light van shown here offers a low-loss drive system, recovery of braking energy and a battery tray which can be quickly removed for routine servicing. It has a standard chassis which is modified for electric drive. The van can maintain a top speed of 80 km/hr and is totally compatible with urban traffic conditions. More than 25 of the prototype vans are being evaluated in commercial service in the U.K., U.S.A., Austria and France *(diagram courtesy of Lucas Batteries Ltd).*

PROTOTYPE VEHICLES PROVIDE OPERATING EXPERIENCE FOR NOVEL PROPULSION SYSTEMS

The "hybrid" vehicle presently being developed by U.S., German and Japanese companies is expected to utilize electric propulsion for slow-speed city driving, and a conventional petrol engine for high-speed highway driving. A microcomputer will automatically monitor driving conditions and distribute the power load to either the electric propulsion system, petrol engine or both (when rapid acceleration is required). Although the hybrid will weigh about 400 kg more than a conventional automobile of the same size, it is expected to consume slightly less energy overall and about half as much hydrocarbon fuel. Daihatsu Motor Company Ltd, which has already built more than 4000 electric and hybrid vehicles, will serve as consultant on the project. Lead-acid batteries of the most advanced design will be supplied by Globe-Union Inc. General Electric Corporation will provide the electric propulsion motor and microcomputer controls *(photograph courtesy of General Electric).*





chemical reactions producing as much as 700 Watt-hours for each kilogram of active electrochemical reactants. In actual practice however, the weight of the battery case, inert electrode material, solvents and other components usually reduce the battery's storage density to about one-fifth of its theoretical maximum.

Nearly all of the advanced battery systems can provide (or are expected to provide, after further development) more than twice the energy storage presently attainable with lead-acid batteries. However, energy storage capacity is only one criterion; the battery must also be able to provide high power (that is, deliver its energy in a short time), withstand hundreds of charge/discharge cycles, be relatively safe in the event of a crash, return most of the energy accepted during charging, and be fabricated cheaply from readily available materials. So far, no advanced battery system has been able to satisfactorily meet all these requirements.

Automobile manufacturers are more interested in electric vehicles now than at any time during the last 60 years. Many manufacturers are building prototype electric vehicles—initially using lead-acid batteries, but to be modified later to accept high-technology batteries. They want to be ready for advanced battery systems when the batteries are ready for them.

Electric propulsion will not, however, answer all transportation problems. Even the most optimistic proponents do not expect electric vehicles to offer the same performance and convenience as is presently provided by petrol-powered automobiles. At best, electric vehicles will comprise only a fraction of the total vehicles produced.

As well as competing with the petrol-powered internal combustion engine, electric propulsion will only be adapted on a wide scale if it proves superior to other high-technology propulsion systems. Notable among them is the internal combustion engine powered by hydrogen fuel. Like electricity, hydrogen could be generated by nuclear or coal-powered plants. It represents an energy storage medium that is more compact and lighter than electrochemical reactants, but would require an entirely new fuel distribution system. Although hydrogen could be stored and shipped in liquid form at cryogenic temperatures, excellent insulation would be required to prevent loss by evaporation. A more practical storage method might be to absorb hydrogen gas into powdered metal alloys, causing reversible formation of a metal hydride. The pressure of hydrogen gas in equilibrium with the hydride is only a few atmospheres. Evolution of hydrogen from a metal hydride requires the application of heat, which can be provided (partly or completely) by the engine exhaust. Thus hydrogen evolution would soon cease if the hydride tank were damaged in a collision.

Iron-titanium hydride is readily dissociated at low temperatures by waste heat of the engine exhaust, releasing about 1.5% its weight of hydrogen. Five times this hydrogen storage capacity is available with magnesium, but the energy required to dissociate magnesium hydride is nearly a third of the combustion energy of the liberated hydrogen. For high-capacity storage systems, some of the hydrogen would probably need to be burned to generate sufficient heat for dissociation of the hydride.

The most impressive sign that hydrogen-powered vehicles are being taken seriously is the research commitment by the Daimler Benz Company, who are presently building more than 20 hydrogen-powered buses and cars (using Fe - Ti hydride storage) to be evaluated in fleet trials.

While hydrogen fuel appears to be ideally suited for certain transportation applications, there is a serious question whether it could ever be practical for widespread use. The outstanding limitations of hydrogen fuel, and its unique benefits in certain applications, were placed in perspective by Dr. Ronald Dell (Group Leader at the UK Atomic Energy Research Establishment), speaking at the Eurochem 80 Conference in June 1980. The main problem of hydrogen fuel, he noted, is low efficiency. Production of hydrogen requires electricity (made by coal or nuclear generating plants) and, as in all heat energy conversion processes, a large share of the input energy (at least 60%) is lost as waste heat. Later, further losses ensue when hydrogen fuel is burned in an automobile engine. Use of hydrogen fuel thus requires two passes through the energy-wasting thermodynamic cycle of a heat engine, rather than one.

The conversion process also means that hydrogen will always be more costly (per unit energy) than the electricity needed to make it. Thus, hydrogen will almost certainly not be used as a fuel in industry, although it will likely be used in increasing amounts as a chemical feedstock to upgrade coal and make synthetic fuels.

There are several applications where the outstanding features of hydrogen are so attractive that they may overcome its high cost and low efficiency of production. Prominent among these is the use of hydrogen as fuel for jet aircraft.

Liquid hydrogen has one-third the weight of conventional hydrocarbon jet fuel of the same energy content. In aircraft, weight is the criterion of paramount importance. On intercontinental flights, the weight of jet fuel may comprise a very significant fraction of the weight of the loaded aircraft. Much of the fuel is expended (and thus, wasted) on transporting its own weight. Although the production of hydrogen entails high costs and energy losses, this would be more than offset by fuel savings using light-weight liquid hydrogen fuel. It is not, in fact, wholly fanciful to expect the next generation of commercial jet aircraft to be hydrogen-powered. The technology to produce, transport and store liquid hydrogen has already been developed for the space programme. Dr. Dell points out that it would probably take no longer to develop a hydrogen-powered aircraft than to design, build and test any new aircraft

(although more engineers and money would likely be required). In fact, Lockheed Aircraft Company (USA) has proposed a demonstration project for a hydrogen-powered freighter.

As far as ground transportation goes, hydrogen fuel offers an alternative to the electric vehicle for pollution-free propulsion in congested or poorly-ventilated areas. Both the EV (Electric Vehicle) and hydrogen-powered vehicle offer the opportunity for *fuel substitution,* and this is the main justification for their development. Drs. McGeehin and Dell state in their paper that the electric vehicle (and the same would apply for hydrogen-powered vehicles) "presents society with a real opportunity to diversify the fuel base of transport from petroleum to nuclear energy and coal . . . The electric vehicle also has major attractions in terms of reducing air pollution in cities."

". . . all fuels and all forms of transport will be required in the future and, for the present, it is important to keep the options open by developing all technical possibilities."

"In the longer term, post 2030, natural petroleum will be in very short supply and it may be necessary to have a large proportion of EVs in the transport sector by then . . . It is this longer term requirement which provides the key strategic reason why the development of EVs, and more particularly advanced traction batteries, must be pursued vigorously today."

Are electrically-powered cars practical? A few views are discharged

The limitations and potential advantages of electrochemical energy storage were clearly outlined at the first International Conference on Electric Vehicle Development, held May -June 1977 in the U.K. Extracted here are a few of the more striking comments made at that conference.

"Electric vehicles came along about the same time as the first internal combustion engined vehicles, the first being constructed in 1888 ... In these early years the electric vehicle was popular and sold well compared with the noisy and inconvenient early internal combustion vehicles. However, a series of developments to petrol-engined vehicles meant that by the beginning of the First World War they had established their dominance. During these halcyon days the electric vehicle fleet in the U.S. grew to over 20 000. The taxis in New York, Boston and Berlin were mainly electric and an electric car held the world land speed record in 1899 at 105 kilometers per hour. In 1910 in London, there were some 6000 electric cars and 4000 commercial vehicles registered."

"Since then, the British electric road vehicle fleet has grown to about 50 000 out of a total western world battery electric vehicle fleet of 300 000 (many of which are not road vehicles)."

D. Bayliss
Chief planner (Transportation)
Greater London Council (UK)

". . we need to use a gallon of petrol (weighting about 4 kg) to derive 5 kWh engine output . . . To derive 5 kWh output from an electric lead-acid storage battery, the battery would weigh about 850 lbs (400 kg) and occupy 7 cubic feet (200 litres). . .One therefore has to recognize that petrol as an energy store is *100 times lighter* than a lead acid battery and takes up *40 times less space.*"

"Energy delivery from a petrol pump is at the rate of 10 gallons per minute, which is . . a 30 Megawatt source. The 13 Ampere domestic electric socket, on the other hand, is a 3 kilowatt source, hence the electrical socket refuels the vehicle 10 000 times more slowly. So a gallon of petrol can be supplied in 1/10th of a minute, but from a 13 Ampere socket the equivalent energy delivery takes 16 hours."

G. Ratcliff
Electricity Council Research Centre (UK)

"About 35 Watt-hours/ton-km are needed to overcome the rolling resistance of a rubber-tyred vehicle. . .If this figure is combined with the figure of an energy content of 35 Watt-hour per kg for lead-acid batteies, it might be concluded that, as a first approximation, one ton-km can be had for each kilogram of battery. It turns out however that the actual figure is worse by a factor of 5 or even more. . .Particularly in city traffic, a considerable amount of energy is needed for acceleration of the vehicle mass. . .It turns out that the energy needed for repeated acceleration is much higher than the energy lost through the rolling resistance."

"The energy used for accelerating the vehicle need not necessarily be wasted; after acceleration it is still there in the form of kinetic energy of the vehicle mass and by regenerative braking part of it can be recovered. . .a portion will (still) be dissipated by the mechanical brakes because the motor is not able to brake the vehicle to a standstill and because occasional traffic conditions may necessitate a rate of deceleration which is higher than can be realized by the motor alone. It is assumed that roughly two-thirds can actually be regenerated."

C. P. Keizer
Delft University of Technology (Netherlands)

How dangerous are laboratory experiments with live bacteria?

Does research with deadly microorganisms subject laboratory workers and the public to serious danger? That question was raised into public view by the tragic death last year of a researcher in a UK laboratory where research was conducted with live smallpox virus. Discussions following the tragedy posed technical and legal questions with sweeping implications. Should researchers conduct research at all with deadly bacteria and viruses (especially with smallpox, which ironically is now thought to have been completely eradicated, except for samples retained for research)? Is research more dangerous when recombinant DNA techniques are used? Was this incident an isolated case, or are all researchers working with live pathogens exposed to danger?

A consensus of viewpoints is beginning to emerge on several key issues. For one thing, early concern with the possible dangers of recombinant DNA research were shown to have been greatly exaggerated. Initially, it had been suggested that a Frankenstein species of artificially-modified bacteria could decimate the human population. Although special procedures are still advised for recombinant DNA experiments, it is now widely recognized that introduction of foreign DNA segments (from humans, animals or other bacteria) into live bacteria is extremely unlikely to create virulent organisms. This has been a most important question, since stringent guidelines have been imposed for containing genetically-altered bacteria. These have restricted experiments to a relatively few laboratories with sophisticated containment facilities. By April 1978, twenty nations had drawn up guidelines for how recombinant DNA experiments should be conducted.

Some researchers feel that the stringent government restraints on recombinant DNA experiments have delayed important medical developments. The enormous potential of recombinant DNA research in the development of new drugs was clearly apparent from discussions at the April 1979 conference "Recombinant DNA and Genetic Experimentation"*, organized by COGENE (International Committee on Genetic Experimentation) and the UK Royal Society. Prof. William Rutter (of the University of California) pointed out that at least one biologically-functional product has been synthesized by bacteria modified with recombinant DNA. This, he feels, demonstrates the feasibility of using bacterial cells as factories to make a wide variety of complex compounds with potent biological activity (such as insulin, antibiotics and interferon).

Recent experimental evidence indicates that microbes in which recombinant DNA molecules are commonly propogated are so enfeebled that they cannot colonise laboratory workers or persist in the environment. There appears to be a negligible chance of producing, by accident, laboratory organisms able to compete with natural bacteria.

Why was this? Walter Bodman (Professor of Genetics at Oxford University) explained at the conference that inter-species genetic exchange occurs in nature, and always has, as part of the normal process of evolution. He pointed out that primitive early organisms were poorly adapted to their environments, and no doubt, benefited from natural changes in their DNA. However, present microorganisms have undergone millions of years of evolutionary adaptation, and are well adapted to their ecological niches.

Mutations and genetic exchange continue to occur frequently in microorganisms, but in nearly all instances, these changes in DNA structure are deleterious to the functioning of the organism. These genetic alterations are part of the evolutionary process. It is advantageous for genetic changes to be introduced at an equilibrium rate; low enough to minimize their deleterious effects on the population of the microorganism, but frequently enough to provide variation among individual organisms so that the species can adapt to environmental changes. The chief factor bringing about biological change, states Prof. Bodmer, is *selection* of traits that are advantageous—and not their introduction by genetic alteration. It is therefore almost impossible, he asserts, for a random recombinant DNA structure to produce an evolutionary advantage for the organism.

Other speakers supported these views. Prof. Alan Campbell (Stanford University) also indicated that natural transfer of plasmids (DNA structures) occurs between a wide variety of bacterial species in nature. He too stressed that natural bacteria populations are highly adapted to their environment, and that changes in biological characteristics result primarily from a change in environment.

The tone of the COGENE conference indicated a developing confidence about the relative safety of recombinant DNA research. But, the conference did not rule out that research with pathogenic bacteria can be hazardous to laboratory workers. And that, in fact, appears to be the case.

To find out how common—and how dangerous—are laboratory-associated infections,

Prof. Robert Pike (at the University of Texas Health Science Center) conducted a survey of the literature and sent questionnaires to biochemical laboratories in the United States. He identified *4079* cases of laboratory-associated infections, of which 168 were fatal. Prof. Pike's findings (summarized in *Arch.Pathol.Lab.Med.,* 102, July 1978, p. 33) show that risks involved with known infectious agents can be evaluated, and appropriate precautions taken. In a few cases, however, an agent not previously encountered may appear. This happened in 1967, when 31 persons, seven of whom died, were infected while handling tissues of African green monkeys. At the conclusion of his article, Prof. Pike presents the possibility that the risk of laboratory infection with known pathogens present in many laboratories is greater than the risk of infection with *E. coli* bacteria used in recombinant DNA experiments.

Could it be that the real danger of laboratory research with pathogens does not lie in artificially-modified microorganisms, but in lethal, naturally-occurring organisms? That question was posed to Dr. A. F. Langlykke, the IUPAC representative to COGENE. He stated to *Chemistry International* that "In any program involving the handling of pathogens, there is a danger of infection . . . as you suggest, the greatest hazard to experimentor and others is encountered in the handling of the naturally-occurring pathogen."

How to minimize that danger was discussed at the COGENE conference by Dr. E. H. Lennette. "The smallpox incident at Birmingham University is an unfortunate illustration of how things may go awry when appropriate safety and containment requirements are breached", he stated. "Two points seem relevant here with respect to potentially hazardous pathogens, naturally-occurring *or* laboratory-contrived. First, no set of laws, regulations or guidelines will ensure the safety of laboratory personnel or containment of the pathogen unless those who work in the field have a full comprehension and understanding of the hazards involved . . . . The second point is the need to bring back to our professional schools and universities courses which . . . give the student the fundamentals of . . . the pathogenesis, pathophysiology and immunology of infectious diseases."

**A Summary Report of the conference was prepared by the Royal Society. Full proceedings of the Conference were published in Jan. 1980, and may be purchased from Pergamon Press.*

Finding data in the chemical haystack: an international approach to the problems

Potentially, the collection of chemical information into computer and printed databases allows the average chemist access to far more information, far more quickly, than was possible before. The capabilities of the chemist working anywhere in the world from a computer terminal are far greater than is presently appreciated, according to Prof. I. D. Brown of McMaster University, Director of one of the two crystallography databases in Canada. In an article published in the January 1980 issue of *Chemistry in Canada,* he asserted that "In the next few years, it is likely that structural data for all known crystals will be available . . . for direct input computer programmes that can, among other things, create stereographic pictures of any known molecule or crystal on a TV screen. Eventually these computer databases may even displace printed journals as the archive for crystal structure data. Improvements in computer hardware, particularly the development of compact memories, small computers and inexpensive graphics terminals, will make these databases as accessible as books and will allow chemists to examine, in a few minutes, aspects of molecular structure that currently take hours or days of library work."

In order for that appraisal to become reality, significant barriers will need to be bridged. A large number of computer databases have been established, and the number is increasing. Finding the nearest database which has exactly the desired information may prove an exasperating chore to many chemists. Equally frustrating might be the plight of a chemist who, after locating the appropriate information source, does not have the expertise required to retrieve the information he needs.

One facet of the problem is being approached by the Committee on Data for Science & Technology (CODATA) of the International Council of Scientific Unions. They are compiling a *Directory of Data Sources for Science & Technology.* Already, CODATA has prepared a chapter on Data Sources in Crystallography (CODATA Bulletin No. 24, 1977). The 42-page booklet contains names and addresses of international and national crystallography projects,

16 data centres located throughout the world, major publication series dealing with crystallography, and a bibliography of 138 publications providing crystallographic data.

Three other Directory chapters relating to chemistry are presently being prepared. These deal with Chemical Thermodynamics, Atomic & Molecular Spectroscopy and Chemical Kinetics. Each chapter will initially be published as a separate CODATA Bulletin (to be available from the CODATA Secretariat, 51 Boulevard de Montmorency, 75016 Paris, France), but ultimately, 15 - 20 chapters dealing with all physical, geological and biological sciences will be updated and combined into a single Directory volume. In addition, CODATA will also prepare a *condensed directory of data sources* for all scientific disciplines. This project, now in the first stages of preparation, is being undertaken for UNESCO.

Both CODATA and IUPAC play an important role in compiling and evaluating data, as well as tabulating data sources. In this respect, activities of the two organizations are closely related, and it is perhaps not surprising that some individuals who are active in the CODATA project are also members of related IUPAC Commissions. Prof. Robert Freeman, who is preparing the CODATA Directory chapter on Chemical Thermodynamics, is also a member of the IUPAC Commission on Thermodynamics. Dr. David Lide Jr., who is compiling the chapter on data sources in Atomic and Molecular Spectroscopy, has been a member of the IUPAC Subcommittee for the Storage & Retrieval of Spectral Data. That subcommittee has recently been dissolved, and in its place, a new IUPAC activity is planned to explore "Computer-based collections of spectral data".

CODATA has published several compilations of evaluated data. A recent report of the CODATA Task Group on Data for Chemical Kinetics deals with Photochemical Data for Atmospheric Chemistry (CODATA Bulletin No. 33, Sept. 1979). It presents rate constants of 148 thermal and photochemical reactions believed to play an important role in atmospheric chemistry. CODATA Bulletin No. 28 presents key thermodynamics values: enthalpies, entropies and heats of formation. The late Prof. Stig Sunner (former Chairman of the IUPAC Commission on Thermodynamics) served as Consultant for its compilation.

This type of data compilation has been undertaken on an expanding scale by IUPAC. Twenty six books have now been published within the *Chemical Data Series*—providing experimentally-measured values of acid - base dissociation constants, stability constants of complexes, ion exchange equilibrium constants, equilibrium constants of liquid - liquid distribution, thermodynamics data, oxidation - reduction potentials, and calibration wavenumbers for infrared spectrometers.

Within the last year, the first volumes of the Solubility Data Series have appeared. When the Series is complete (in about 10 years), it will be the largest and most comprehensive compilation and critical evaluation of solubility ever attempted. Ultimately, the Series will comprise 80 - 100 volumes (see *Chemistry International,* 1979, No. 3, p. 7).

The IUPAC Commission on High Temperatures & Refractory Materials is preparing a computer tape for a "Thermochemical Data Bank", containing heat content, entropy, Free Energy functions and vapour pressure data of 1400 inorganic compounds. In addition, the "Thermochemical Data Bank" will be published in several installments this year in the *Bibliography on the High Temperature Chemistry and Physics of Materials.*

Several publications are already available to help guide chemists through the computerized maze of chemical data. "Among other sources", writes Dr. Gérard Emptoz (editor of the CODATA Directory), "a book entitled 'How to Find Chemical Information' provides chemists with practical information relevant to the use of data bases. More generally, an annual survey of information activities is made by the 'Annual Review of Information Science and Technology', edited by Martha E. Williams, and published by the American Association of Information Science, U.S.A."

Even when the correct data source has been located, the main challenge for finding information often remains: how to retrieve desired information about a given chemical formula structure, or identify a material from its spectrum. To find this type of information, the help of an information specialist may be invaluable. Complicating the difficulties involved, no universal system of structure searching and manipulation has yet been adopted, as was pointed out by Janet Ash and coworker E. Hyde in their lecture to the IUPAC International Symposium on Techniques for the Retrieval of Chemical Information* (held November 1976). "The global needs (for storage and retrieval of organic chemical structures) have never been evaluated", they concluded, "and nearly all progress in the field of structure systems has been made by individuals fulfilling local needs." What is lacking, they feel, is a unified form for structural data and the universal adoption of a registry system.

Once computer storage and retrieval techniques have become standardized, how rapidly will the revolution in information technology take root in chemical laboratories throughout the world? The rate-limiting step is not the introduction of further technological advances, as Prof. Brown indicated to *Chemistry International.* The change, he feels, "will come as quickly as chemists are ready to accept it."

**The main lectures presented at the IUPAC International Symposium on Techniques for the Retrieval of Chemical Information are published in Pure & Applied Chemistry, Vol. 49, No. 12, 1977.*

Vancouver (Canada), site of the 1981 IUPAC Congress, is shown in the photo below. Above is Maligne Lake, the largest glacier-fed lake in the world, situated in the Canadian Rocky Mountains (*photos courtesy of the Canadian Government Tourist Office*).

Next summer, take the IUPAC **North America Expedition***

North America will be the setting for several major international chemistry conferences during summer 1981. Notable among these are the IUPAC Congress and the IUPAC-sponsored International Conference on Chemical Education. Why not use these conferences as a base to explore the scientific, and non-scientific, attractions of the North American continent?

In this article, *Chemistry International* previews some of these attractions, describes how you might make the most of your trip, and offers a free information package of conference programmes, information guides, visa application forms and tour brochures.

*Participants in the IUPAC North America Expedition are responsible for their own conference registration, travel, accommodation and other travel arrangements. Information provided here and in the expedition packet is up-to-date at the time of writing. Participants should confirm schedules and prices. Neither IUPAC nor *Chemistry International* accept responsibility other than to provide information and suggestions which we believe in good faith to be accurate and useful.

The 1981 IUPAC Congress is much more than one of the largest (if not *the* largest) international chemistry conference to be held. Its scientific program represents a bonanza of chemical topics of current interest. It is inconceivable that any living chemist would not find material to arouse his interest and expand his knowledge within the eight major fields encompassed by the Congress: Chemistry in the solution of energy problems, Chemistry in the study of the environment, Chemistry in the upgrading of resources, Computers in chemistry, Analytical chemistry, Inorganic chemistry, Organic chemistry and Physical chemistry.

For those scientists who wish to use the IUPAC Congress as a base to explore the chemical and physical attractions of North America, the Congress is conveniently positioned in time and space. Its scheduling for 16-22 August allows attendance at two other major chemistry conferences immediately before and after the Congress: the 6th International Conference on Chemical Education, and the Fall Meeting of the American Chemical Society. The Congress site in Vancouver places delegates at the center of the spectacular scenery of one of the most attractive areas of the North American continent.

In addition to lectures and poster sessions, the Congress will offer an opportunity for delegates to explore unique industrial and research facilities located nearby, and to meet colleagues from North America and other continents. One of the tours available to conference delegates will visit the giant Syncrude plant, which spearheads Canada's drive to develop new energy resources. The plant processes Alberta tar sands into synthetic crude oil, producing an output of 129,000 barrels/day. More important, the Syncrude plant provides experience for further development of this enormous non-conventional energy deposit. Buried deep beneath the Albertan landscape lies 1000 billion barrels of hydrocarbons—more than the petroleum reserves of the Middle East. Except for the Orinoco heavy oil belt of Venezuela, the Alberta tar sands are the largest hydrocarbon deposit in the world.

Although visits to other industrial sites have not been arranged, the Congress organizing committee will assist individuals wishing to visit nearby government research laboratories, oil refineries, sawmills, pulp converting plants, cement and caustic soda/chlorine manufacturers.

The Congress will provide an informal environment for participants to meet and discuss their interests. A complimentary inaugural reception, coffee breaks, Congress banquet (on the grounds of the Museum of Archeology), and a series of dinners for delegates with related scientific interests are planned. Delegates can take advantage of a choice of tours of the University of British Columbia, City of Vancouver, Vancouver's Chinatown (the second largest Chinese community in North America), Vancouver harbour and the scenic mountainous environs of Vancouver.

Of special interest to editors of primary chemistry journals is a seminar to be held within the IUPAC Congress. The seminar is intended to assemble for the first time chemistry journal editors to discuss the present status and future directions of chemistry publications. Consideration will be given to setting up a forum for editors, possibly as an IUPAC committee, to act as an ongoing link between IUPAC and journal editors. It is hoped that the forum might provide input to IUPAC's formulation of nomenclature, and subsequently, promote wide dissemination of nomenclature recommendations to achieve worldwide standardization.

Overseas visitors will likely be pleasantly surprised at the relatively low cost of accommodation, meals and travel within North America. Low-cost accommodation for the Congress is available in residences of the University of British Columbia. In most residences, six single bedrooms are grouped around a common sitting room and bathroom. The cost is expected to be about C$16/day for a single adult. Since August is a popular time to visit Vancouver, participants should submit their requests for accommodation as early as possible. More elaborate facilities are available at hotels in central Vancouver, which are accessible to the University by regular public bus transportation. Hotel rates vary from as little as C$48 for a single room to C$88 for a double room (for a couple or small family).

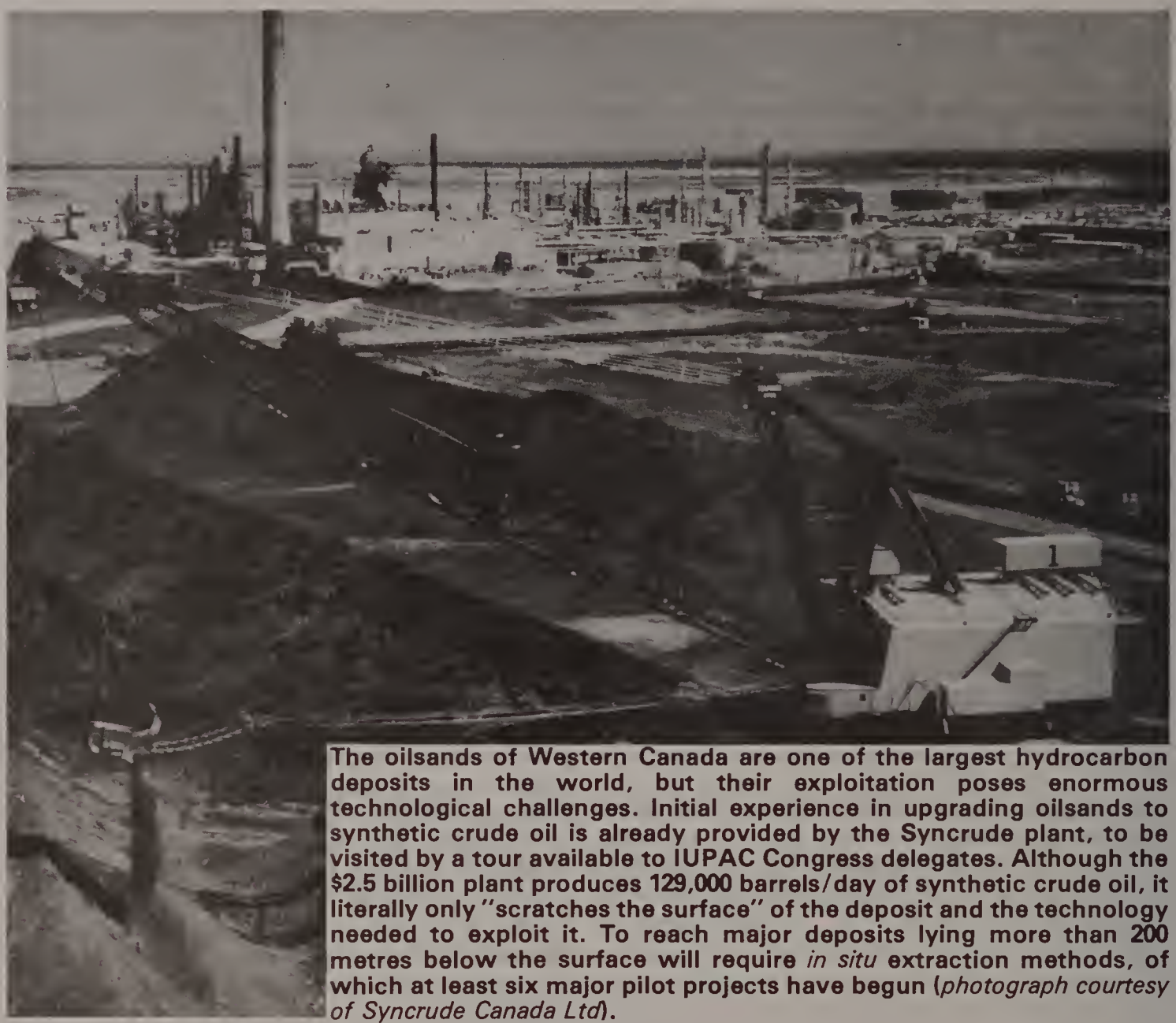
Before landing in Vancouver to attend the IUPAC Congress, you might wish to participate in several other major chemistry conferences to be held the previous week. Particularly of interest to university chemists is the *6th International Conference on Chemical Education.* It will be held at the University of Maryland, just outside Washington D.C. The Conference is sponsored by IUPAC and the American Chemical Society in collaboration with UNESCO. Further details may be obtained from the Conference Manager: Prof. H. Heikkinen, Dept. of Chemistry, University of Maryland, College Park, Maryland 20742, USA.

If your interest is not chemical education, but is organometallic chemistry, you might wish to attend the IUPAC-sponsored *10th International Conference on Organometallic Chemistry,* to be held (also August 9 - 14) in Toronto, in Eastern Canada. This week preceding the IUPAC Congress would be free for sightseeing in the Western USA and Canada if you attend instead the *International Symposium on Organometallic Chemistry Directed to Organic Synthesis,* to be held August 2 - 6 in Colorado (USA). Further information on these conferences can be obtained by writing to the conference organizers (addresses are provided in the listing of IUPAC-sponsored conferences in this issue.

Most overseas visitors entering the United States will need to obtain an entry visa. Visas should be requested well in advance, and you will need to submit your passport with the application. Provided that the application is made not less than 3 months in advance, IUPAC sponsorship of conferences implies that entry visas will be granted to all bona fide chemists who wish to attend. If a visa has not been granted one month before the meeting, the applicant should notify the IUPAC Secretariat without delay.

It is not required that you obtain health insurance for your visit to North America, but this is strongly recommended. If you become ill, your national health insurance may not cover the very high cost of hospital services in North America (about $100 -200/day in Canada, and even more in the USA).

Because North America is such a large continent,



The oilsands of Western Canada are one of the largest hydrocarbon deposits in the world, but their exploitation poses enormous technological challenges. Initial experience in upgrading oilsands to synthetic crude oil is already provided by the Syncrude plant, to be visited by a tour available to IUPAC Congress delegates. Although the $2.5 billion plant produces 129,000 barrels/day of synthetic crude oil, it literally only "scratches the surface" of the deposit and the technology needed to exploit it. To reach major deposits lying more than 200 metres below the surface will require *in situ* extraction methods, of which at least six major pilot projects have begun (*photograph courtesy of Syncrude Canada Ltd*).

travelling long distances is more commonplace and accepted than in Europe. Although fuel costs have been spiralling upwards, transportation is still (by European standards) a bargain, generally costing about half as much (per kilometre travelled) as air travel within Europe. What's more, some airlines offer special low fares to overseas visitors for travel within North America—provided that they book their flight *well in advance* and *from their home country*. If you attend the Chemical Education Conference in Maryland, you can fly via United Airlines to Vancouver (via Chicago with direct connection) to attend the IUPAC Congress at a special 40% discount "Visitors Fare". The discount fare, US$153 in summer 1980 is only offered for a limited number of seats. To obtain the discount, you will likely need to book the flight early and you must obtain the tickets before arrival in the USA.

In order to enter Canada, you will *not* need a visa if you are a British subject, a citizen of a Commonwealth country (except Nigeria), or a citizen of Ireland, France or the Republic of South Africa. The same is true for visitors from the following countries: persons born in any country of the Western Hemisphere or adjacent islands (except Columbia), and citizens of Austria, Belgium, Denmark, Finland, Federal Republic of Germany, Greece, Iceland, Japan, Liechtenstein, Luxembourg, Monaco, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, Turkey, or the Netherlands. If you plan to work in Canada, stay more than 90 days or are in doubt about whether you need a Canadian entry visa, write to the Canadian Immigration Division, Canada Employment and Immigration Commission, Ottawa, Ontario K1A 0J9, Canada.

Delegates who do not expect to attend the 6th Int. Conference on Chemical Education can proceed to the IUPAC Congress at a more leisurely pace, and enjoy a choice of routes. Delegates who will be travelling westbound to Vancouver should consider the possibility of terminating their flight at Calgary (or Edmonton) and then proceeding through the spectacular scenery of the Rockies by car or by train. The distance is about 1000 km and by car it can be accomplished easily with one overnight stop. The train leaves Calgary at 1650 hours and arrives in Vancouver at 1305 the following day (1980 schedule).

A more extensive tour of Western Canada has been arranged by the conference organizers in collaboration with a private tour operator. For the week preceding the Congress, a seven-day motorcoach tour is available to take delegates from Calgary to Banff, Lake Louise, Jasper, Kamloops, and finally Vancouver. The tour, inclusive of most meals and twin accommodation, costs C$695 per person (1980 rate; 1981 tours are expected to cost about 15% more).

At the conclusion of the IUPAC Congress, Van-

couver will be an excellent base camp to explore the spectacular scenery of the Canadian Rockies, or as a step-off point on the homeward journey. A technical tour available to Congress delegates is highlighted by a visit to the Syncrude processing plant (which produces synthetic crude oil from Alberta's tar sands, one of the world's major non-conventional hydrocarbon resources). The four-day tour takes delegates by air to Calgary, and then to Banff, Edmonton and Fort McMurray. The tour, which ends in Edmonton, costs C$475/person.

Delegates on their return to Asia and the South Pacific might consider the tour of Hawaii. Departing August 22 from Vancouver by air, the seven-day tour will take delegates to the Hawaiin islands of Maui and Oahu. The cost is C$398 per person.

In addition to tours offered specifically to IUPAC Congress delegates, Gray Line offers a range of coach tours providing magnificent views of the rugged mountains, glaciers, lakes and forests of Western Canada. Those with limited time can touch all the highlights with a two-day Vancouver-to-Calgary Summit Tour. A tour departs each day from Vancouver, and costs about C$180 (including 4 meals and single room accommodation). Those with more time can take a three-day Vancouver-to-Jasper tour, or Vancouver-to-Calgary tours lasting 4, 6 or 7 days. Reservations are necessary on all tours, and payment is due 45 days prior to tour departure. Information requests and reservations should be addressed to Royal Glacier Tours, Box 1140, Banff, Alberta, Canada T0L 0C0.

Railroad enthusiasts would likely appreciate views of the Rockies on an unescorted railway tour. An *Alberta Discoverer* Tour departs Monday August 23rd from Vancouver in a seven-day round-trip journey through Calgary, Edmonton and Jasper. On the same day, a *British Columbia Discoverer* train tour takes the track north to Jasper, Prince George and Prince Rupert, returning six days later to Vancouver. Prices for the two tours are about C$300 -350 and C$500 respectively. Once again, reservations should be requested as far in advance as possible. Additional information is available from VIA Rail Canada, 17 Cockspur Street, London SW1Y 5BS, UK

Those whose appetite for chemistry has not been satiated should not take the time to explore Western Canada, but should immediately fly east in order to be at the opening of the American Chemical Society Fall Meeting in New York City. You can fly from Vancouver to New York via United Airlines, and again, you may be able to obtain a 40% discount on the fare (US$145 in summer 1980) by booking the flight well in advance *before you depart* for North America.

Biochemists would likely wish to fly south to Mexico City, where the 3rd Pan-American Biochemistry Congress and the 7th International Biophysics Congress will be underway from 23 - 29 August. The principal aim of this event is to bring together scientists engaged in various fields of biochemistry, biophysics and other biological and physical sciences. The scientific program includes lectures, symposia, workshops and free communications. Also, satellite activities and an International School of Biophysics are scheduled. For further information, write to the Secretariat, 3rd Pan-American Biochemistry Congress, Cerrada de Popocatepetl No. 51-A, Mexico 13, D.F. MEXICO.

Whether you will be flying directly home from the IUPAC Congress, or elsewhere within North America, you can probably get where you're going by an Air Canada or CP Air Flight. Air Canada has direct flights between Vancouver and New York, Frankfurt and London (non-stop). The CP Air network includes Australia, the Far East and South

Scientific Program 1981 IUPAC Congress

The program is organized into eight major topics. Each topic is further divided into specific areas, in which will be presented a keynote lecture, verbal presentations (20 minutes each) and poster presentations.

(1) CHEMISTRY IN THE SOLUTION OF ENERGY PROBLEMS
- Energy related topics in chemistry
- Electrochemistry, applications to energy storage
- Combustion processes and fossil fuel conversion

(2) CHEMISTRY IN THE STUDY OF THE ENVIRONMENT
- Chemistry of the atmosphere
- Chemistry/biochemistry of waste water treatment
- Chemical oceanography, incl. marine biochemistry
- Corrosion

(3) CHEMISTRY IN THE BENEFITIATION (UPGRADING) OF RESOURCES
- Extractive metallurgical chemistry (incl. Uranium)
- Soils chemistry
- Pulp and paper chemistry
- Biochemistry and biotechnology

(4) COMPUTERS IN CHEMISTRY
- Calculation of molecular structure & mechanisms
- Computer applications in theoretical chemistry
- Microprocessors in chemical instrum. & processing
- Computer-aided strategies in chemistry

(5) ANALYTICAL CHEMISTRY
- Applications of mass spectrometry in analysis
- Analytical chemistry in biology and medicine
- Instrumental methods in analytical chemistry

(6) INORGANIC CHEMISTRY
- Plasma chemistry and novel synthetic methods
- Transition metal chemistry
- Bioinorganic chemistry
- Main group chemistry

(7) ORGANIC CHEMISTRY
- Biosynthesis of natural products
- Biomimetic chemistry
- Novel structures & synthetic organic chemistry
- Mechanisms in organic & bioorganic reactions
- Medicinal chemistry and drug metabolism

(8) PHYSICAL CHEMISTRY
- Surface chemistry and catalysis
- Macromolecules and colloids
- Novel methods of determining molecular structure
- Radiation chemistry, electrons in fluids & solids
- Lasers in chemistry

EXPEDITION CHECK LIST

(1) Have you registered for the IUPAC Congress, and other conferences which you plan to attend?

(2) Have you checked that your passport has not expired?

(3) Have you booked your flight to/from North America, and flights for travel within North America? Book your flights early to obtain guaranteed flight reservations at the lowest fare.

(4) Have you checked if you need a US and Canadian entry visa, and applied for those required? You should apply at least 3 months in advance.

(5) Have you booked all major tours you wish to take?

(6) Have you obtained health insurance? (strongly recommended)

(7) Have you obtained traveler's cheques in US and Canadian currency? Some currencies may be exchanged at airports or banks. Most hotels and restaurants will not accept personal cheques.

(8) If you wish to use your electric shaver, hair dryer or other appliances, have you obtained an electrical converter and adaptor? (Electricity supply in the US and Canada is 110 volts A.C.)

(9) Planning to hire a car? If so, bring your driver's license. Unless you are prepared to pay a large cash deposit, you will need to have a credit card accepted in North America (Mastercharge, Visa, American Express or Diners Club).

America in addition to Europe and North America. Direct flights on CP Air are available from Sydney, Hong-Kong, Tokyo, Los Angeles, Buenos Aires, Amsterdam (non-stop), Milan and Athens.

Members of IUPAC bodies can depart Vancouver on daily CP Air flights (through Amsterdam) or Air Canada (through London, UK), to arrive at Leuvain, Belgium in time for the opening of IUPAC's 31st General Assembly on August 25th.

Delegates leaving the Vancouver Congress enroute to Europe are advised to avoid routes via Montreal since these usually involve a change of airport (Dorval to Mirabel), unless of course, you wish to stop in Eastern Canada.

Advance booking of your flight to, and from, North America will be an important factor keeping down the cost of your North America Expedition. You can generally save a substantial amount by advance booking of Apex or excursion flights. For example, the "Maple Leaf" round-trip London - Vancouver fare of £336 is 40% less than the regular 14 - 60 day excursion fare. Savings are not usually as great as this, but are usually significant. The Tokyo - Vancouver Apex fare of 21 300 Yen is 13% cheaper than the regular round-trip fare. A 19% saving is realized with the peak-season Apex Sydney - Vancouver fare of A$1248, and a 12% reduction is available with the US$1543 14-28 day excursion fare from Buenos Aires (all fares quoted were correct as of summer 1980, and might be expected to increase by about 15 - 20%).

Jet travel offers far greater speed, comfort and safety than was ever imagined possible by earlier explorers arriving on the shores of North America. You must, however, contend with one inconvenience never faced by Captain Cook (who established a small observatory on Vancouver Island during his third expedition across the Pacific Ocean in 1775-1779): jet-lag. After travelling through several time zones in a matter of hours, your body will need at least a day to adapt. With the excitement of landing in this new world, you will probably want to explore the entire continent on the first day. But after the adrenalin flow subsides in the first few hours, you will probably be too tired and disoriented to concentrate on chemistry or exploration. Allow yourself a quiet day's respite before undertaking the first major exploration of this strange and different world.

About the author:
As a US citizen and recent resident in Canada, the editor has a good working knowledge of the North American scene. He is also one of the world's leading experts on jet-lag, having flown twice to Australia. Since his last journey in December 1978, he is still confused about the month of the year and which way to look while crossing the street.

Dr. Gellender's most recent accomplishments include mastering the European technique for making telephone calls (in North America, coins are deposited before dialling), and turning on light bulbs (pressing wall switches downwards, rather than upwards as is standard in North America).

To assist those wishing to undertake the 1981 North America Expedition, *Chemistry International* is assembling an information package containing conference brochures and registration forms, visa application forms, information for foreign visitors to the US and Canada and tourist brochures for selected attractions around Vancouver and Washington D.C. The information package may be obtained free-of-charge by writing to Dr. M. Gellender, Editor *Chemistry International,* IUPAC, 2 - 3 Pound Way, Cowley Centre, Oxford OX3 3YF, UK

Agricultural products— Raw material and energy source of the future

Coal and agricultural products are most likely to follow petroleum as primary sources of chemical feedstocks and fuels. The speed and extent at which they replace petroleum will depend largely upon the price of oil and the ease with which they are converted into basic chemicals that fit into present petrochemical processing systems.

A major advantage of oil as a feedstock for the chemical industry has been that a few simple chemical components can be produced in large, centralized, highly economical petrochemical refineries. These compounds can, in turn, be converted into a wide variety of chemical products.

Developments in coal chemistry are moving towards gasification and liquefaction to carbon monoxide, hydrogen and hydrocarbons. These can be converted into a multitude of chemicals and fuels by conventional techniques.

So too for agricultural products—biomass—it is a question of finding processes that produce basic chemicals such as ethanol, ethylene, methanol or simple aromatics.

by Prof. Dr. Karl Heinz Büchel
Member, Bayer AG Board of Management
Chairman, IUPAC Committee on Chemistry & Industry

Until well into the 19th century, agriculture and forestry provided the main raw materials for foodstuffs, organic chemical products and energy.

Then, around the middle of the last century, the raw material and energy situation underwent a sudden change. Coal began its reign as the provider of energy for the industrial age. Coal tar, obtained during the production of coke for iron smelting, proved to be an inexpensive and virtually inexhaustible feedstock for the manufacture of synthetic organic chemicals. In the years that followed, aromatic compounds contained in coal tar became the basic raw material for the dyestuffs industry. The dyestuffs were followed by pharmaceuticals and agricultural chemicals. Conversion of coal into acetylene or synthesis gas broadened the basis of raw materials further, and the range of chemical products expanded rapidly with the development of synthetic rubber, plastics and synthetic fibres.

Another fundamental change took place in the middle of the 20th century, starting in America. Coal was largely replaced by crude oil and natural gas as a raw material and energy source. Oil and gas were cheaper and easier to process, were apparently available in surplus at favourable prices, and had a composition that was particularly suited for the chemical industry. The changeover to oil and gas as a basic feedstock for organic chemistry took place surprisingly quickly after 1950 and without any major technical difficulties. It enabled the chemical industry to grow very rapidly indeed: in the last 30 years the production of organic chemicals has increased more than tenfold. The share of chemical products derived from petroleum rose from 44 to 95%—the small remainder being produced from coal and biological raw materials.

The chemical industry uses only a small percentage—around 6% of total oil supplies. The major share by far, 94%, is burnt in power stations, heating systems and combustion engines for generating energy. However, because the energy market and the relatively small feedstock market are so intertwined, the supply of feedstocks to the chemical industry is directly affected by changes in energy supply and demand.

Such changes occurred during the oil crisis of 1973. Since then, the price of crude oil has increased tenfold. For the first time, there was widespread realization that oil reserves would be used up within a few decades at present rates of consumption. These events triggered an intensive worldwide search for alternative feedstock and energy sources—sources that, if possible, would be renewable every year.

According to the opinion of experts, there will be a major change in our energy and raw material supply

Conversion of sugar cane to motor fuel is being undertaken on a massive and expanding scale in Brazil. Here, the sugar cane (photo right, courtesy of Bergmann/ laenderpress, Düsseldorf) is being brought to an ethanol plant in Pradopolis-Ribeirao Preto, in the Brazilian state of Sao Paulo (photo center). At the ethanol plant, the cane is processed, fermented and distilled. The ethanol product is used directly in test automobiles (like this telephone company car in Sao Paulo), or is mixed with gasoline and sold to motorists.

structure over the next twenty years. Nuclear power and coal will take over a growing proportion of energy requirements. Oil and gas, being ideal raw materials for the chemical industry, need to be reserved for feedstocks as long as possible. At the same time, coal will also experience a renaissance as a chemical feedstock through its gasification and liquefaction. The enormous deposits of oil sand and oil shale must be developed and, finally, there are great hopes that renewable, natural raw materials—biomass—will make a long-term contribution to our raw material resources.

These developments are likely to take place in overlapping stages during the coming decades. The timetable of their occurrence is largely dependent on the availability and price of oil. It is this that determines the economic viability of alternative raw materials. Special factors relating to supply, financing and social policy can greatly accelerate a particular course of development in individual countries.

Biomass—future feedstock & energy source

For organic chemistry, the question of raw materials of the future is the question of alternative carbon sources. Carbon dioxide in the air represents a virtually inexhaustible reservoir of carbon. Green plants utilize the unlimited supply of solar energy to convert carbon dioxide and water into organic substances. These are mainly carbohydrates such as sugar and starch, but also include proteins, fats and hydrocarbons. Recent calculations have shown that, throughout the world, approx. 2×10^{11} tons of biomass with an energy content of 3×10^{21} joules are presently produced on land every year. By the term "biomass", we broadly mean all products of photosynthesis—in other words, all vegetable and animal material as well as agricultural, forestry, municipal and industrial biological waste products.

The present production of biomass is around 1,000 times as much as the oil used for manufacturing all chemical products, about 10 times as much as the present world energy consumption and 200 times as much as the energy needed for the production of foodstuffs. Only about 1% of the biomass is presently used for the production of energy and fibres, and about 1% for food and feedstuffs. The vast majority of the biomass "rots" unused. Most is converted by bacteria back to carbon dioxide and water, or mineralized, which means that it is completely lost to us as a source of feedstocks or as a source of energy.

It is certainly not a new idea for the chemical industry to use these renewable raw materials; until fossil carbon sources (coal, oil and gas) were exploited, renewable materials were the *only* organic raw material source. Even today, a large number of chemical products are based on them. We need only think of commodity products such as natural rubber, fatty acids, ethanol, and of special products like essential oils, citric acid, enzymes, antibiotics and pharmaceuticals from medicinal plants. It is estimated that in the USA, these chemical products account for 2 - 3% of the total organic chemical production (1977). However, it is unlikely that the demand for these specialty products—most of which are complex substances preformed in biological systems—will increase to an enormous extent. With the exception of ethanol, these substances can hardly be considered for a broad utilization of biomass.

There are presently four main chemical and microbial processes available for converting biomass (which consists mainly of carbohydrates such as cellulose, starch or sugar) into basic chemicals:

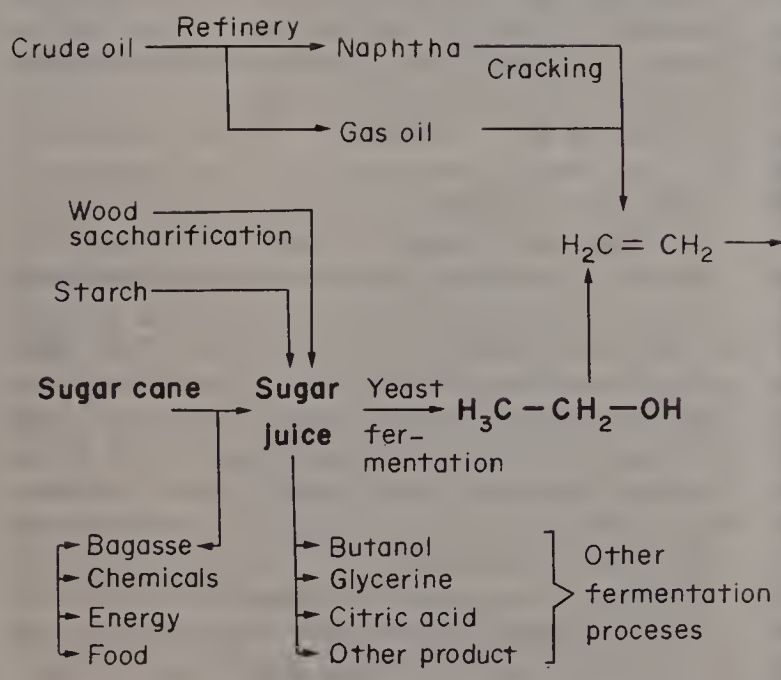
Fermentation is the microbial conversion of sugar and starch contained in plant material. It leads (either directly or, in the case of starch, after purely enzymatic hydrolysis) to ethanol or other products such as glycerin, acetone, fumaric acid and methane.

Pyrolysis of wood (thermal cracking in the absence of air) leads to methanol, acetic acid and charcoal.

Partical oxidation of wood or cellulosic waste gives a mixture of hydrogen and carbon monoxide similar to synthesis gas.

Hydrolysis of wood (chemical or enzymatic) forms sugar, which can be further fermented to give ethanol. Lignin, the substance holding cellulose fibres together, can be processed into aromatics such as phenol.

Projects dealing with the use of biomass as chemical feedstock and energy source are at present being carried out all over the world. In the USA, a recently published "bio-energy directory" contains nearly 500 such projects!



Biomass could be an alternative feedstock for making ethylene and other chemicals presently made from crude oil. One likely route is by fermentation of sugar, which would be carried out in an ethanol fermentation/distillation plant such as the one shown here. Upon undergoing dehydration, the ethanol yields ethylene.

Ethanol from sugar cane

The most famous project concerning the use of agricultural products is the "National Alcohol Programme" started by the Brazilian government in 1975. The programme is aimed at reducing Brazil's dependence on oil imports (amounting to US$7 billion in 1979, and accounting for more than a third of the country's total imports), creating new jobs and bringing about a uniform industrial structure. To do this, facilities are being installed for large-scale production of ethanol by fermentation from sugar cane, molasses and cassava starch (after enzymatic hydrolysis).

In Brazil, an ambitious investment programme, financed by US$5 billion, is planned to increase production capacity of fermentation alcohol to 10.5 million m^3 by 1985. Already, more than 200 ethanol plants with a total capacity of 4.7 million m^3 have been approved by the Brazilian government. The aim is to provide enough chemical ethanol in 1985 to operate one million automobiles on ethanol, and the rest on a mixture of 80% gasoline and 20% ethanol.

At the present time, there are a number of test autos on the road using ethanol as fuel. In the state of Sao Paulo, it is already quite common for 15-20% ethanol to be added to gasoline. The Volkswagen Company recently began commercial production of a special engine, which it developed to operate on ethanol fuel. At Daimler-Benz, work is in progress on developing a diesel engine using only ethanol as fuel. If successful, the new engine could decisively ease the diesel fuel demand of Brazil's transport system.

The Brazilian ethanol programme also provides for the large-scale use of ethanol as a chemical feedstock. Fermentation ethanol has already been used for several decades to manufacture chemical products in Brazil. Today, the government is supporting ethanol-based chemical production within the framework of the National Alcohol Programme. Ethanol is a very versatile chemical feedstock and can be converted into a large number of chemicals. Particularly important is the simple conversion of ethanol into ethylene (through the splitting off of water) and—using the Mobil process—into ethylene, propylene, C_4-C_{10} hydrocarbons (gasoline) or aromatics. These hydrocarbons provide a link back into existing petrochemical technology. In Brazil, chemical plants making nearly 300 million tons/year of chemical products are already operating, or are being planned, that will use feedstocks derived from fermentation alcohol.

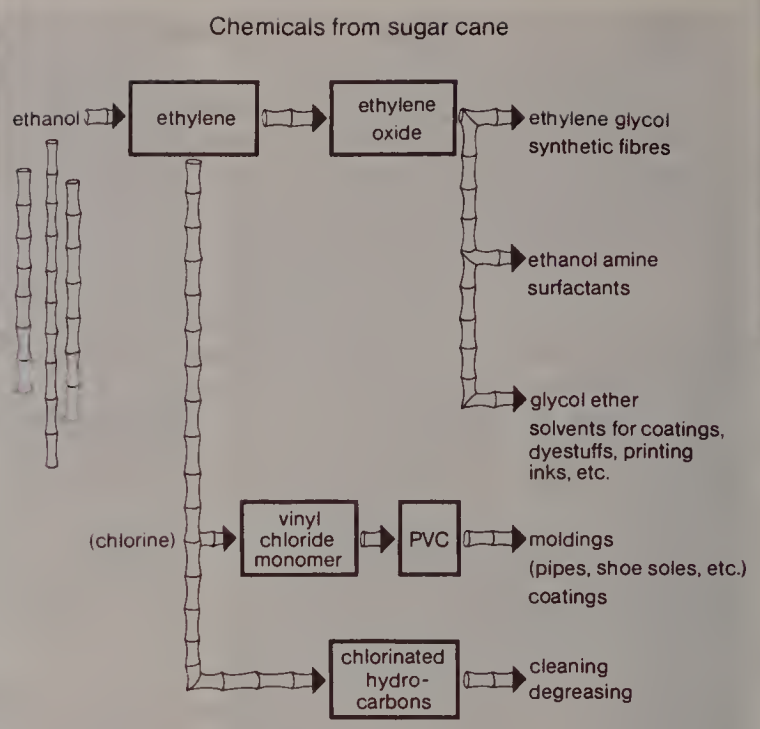
In wide areas of Brazil, conditions for growing sugar cane are ideal. At present, 2.2 million hectares are cultivated with sugar cane. It is thought that this area could, in principle, be increased tenfold to around 20 million hectares—about half the useful agricultural area of Brazil (without pasture land). This would only be possible if use were made of land that had never been used for agricultural purposes.

Sugar cane is an ideal plant for "energy farming". Each hectare of cultivated area produces 35-90 tons of dry sugar cane biomass every year. This is significantly higher than for crops such as maize, wheat or sugar beet. In terms of total heat energy, one hundred tons of sugar cane is equivalent to 70 tons of coal, or 40 tons of oil. Much of the energy of sugar cane is contained within its sugar content (comprising 13-14% of the weight of the cane). A hundred tons of sugar cane yield about 6.5 tons of ethanol. The fibrous remains of sugar cane, termed "bagasse", can be burned to provide all the energy required for fermentation and distillation.

Even without expanding sugar cane cultivation, the potential for ethanol production in Brazil is impressive. If the 1977 sugar cane harvest of 120 million tons were converted entirely to ethanol, it would be possible (at least according to simple calculations with our model agricultural system) to produce 7.8 million tons of ethanol.

To reach the production goal targeted for 1985, the area cultivated with sugar cane is to be increased from 2.2 million hectares to 3.5 million hectares (9.3% of the useful agricultural land). This could provide an ultimate ethanol yield of 12.4 million tons (half the present consumption of motor fuel). The possibility of increasing sugar cane acreage to as much as 20 million hectares clearly shows the enormous potential of sugar cane as a feedstock and energy plant in Brazil.

However, it is uncertain whether this vast raw material potential can be fully utilized in view of food policies and the existing agricultural structure. The model nevertheless clearly shows that present ethanol plans for Brazil are realistic and can make an effective contribution to the country's supply of feedstocks and energy. The production of ethanol from sugar cane is not yet economic—if we disregard benefits to the national economy—but it is likely that the break-even point will soon come about with improved cultivation and fermentation methods and further oil price increases.



Sugar-derived ethanol is a versatile raw material for chemical manufacture. Once ethanol is converted to ethylene, it can be used to produce a wide variety of chemical products (*diagram courtesy of Rhone-Poulenc*).

Ethanol from grain & sugar beet

It is not only developing countries with little oil (like Brazil) that are interested in producing ethanol from sugar or starch. In the USA, there has been considerable discussion about the possible introduction of a fuel mixture called "gasohol", consisting of 90% gasoline and 10% fermentation alcohol from grain (chiefly maize). The American Department of Agriculture has investigated the economic viability of a "national gasohol program" in the United States. Their provisional calculations assume the construction of 500 fermentation and distillation plants, producing 40 million m^3 ethanol (approx. 30 million tons). They project that such a programme would require an investment of at least US $15 billion, and that a state subsidy of US $10 billion/year would be needed to make fermentation alcohol competitive as a fuel. There are no plans at present for implementing such a large-scale programme in the United States, but it is the subject of much lively discussion. The consequences would be considerable, not only for agricultural and food policy but also for the national economy. Regardless of this decision, the USA must continue to investigate production of fuels from coal and oil shale.

Conditions in densely populated, highly industrialized countries like West Germany are very different from Brazil or the USA. There, sugar beets (containing about 13% sugar) could be fermented to ethanol, providing small amounts of liquid fuel. The West German sugar beet harvest of about 19 million tons in 1978 contained about 2.5 million tons of sugar. From this, it would theoretically be possible to obtain about 1.75 million m^3 (1.4 million tons) of ethanol. This represents only about 5% of West Germany's annual gasoline consumption! Thus ethanol from sugar beet is unlikely to play a major role as an energy source in Germany, even if there were a shift in crop ratios.

Methanol from wood—tree farming

The thermal cracking of wood in the absence of air (pyrolysis) has long been utilized for the production of methanol (wood spirit). Recently, this method has come under consideration for the production of methanol as a fuel/additive or chemical feedstock. Methanol can be converted by zeolite catalysts to simple aliphatic and aromatic hydrocarbons. These petrochemicals can then be converted by conventional processes into other chemical products.

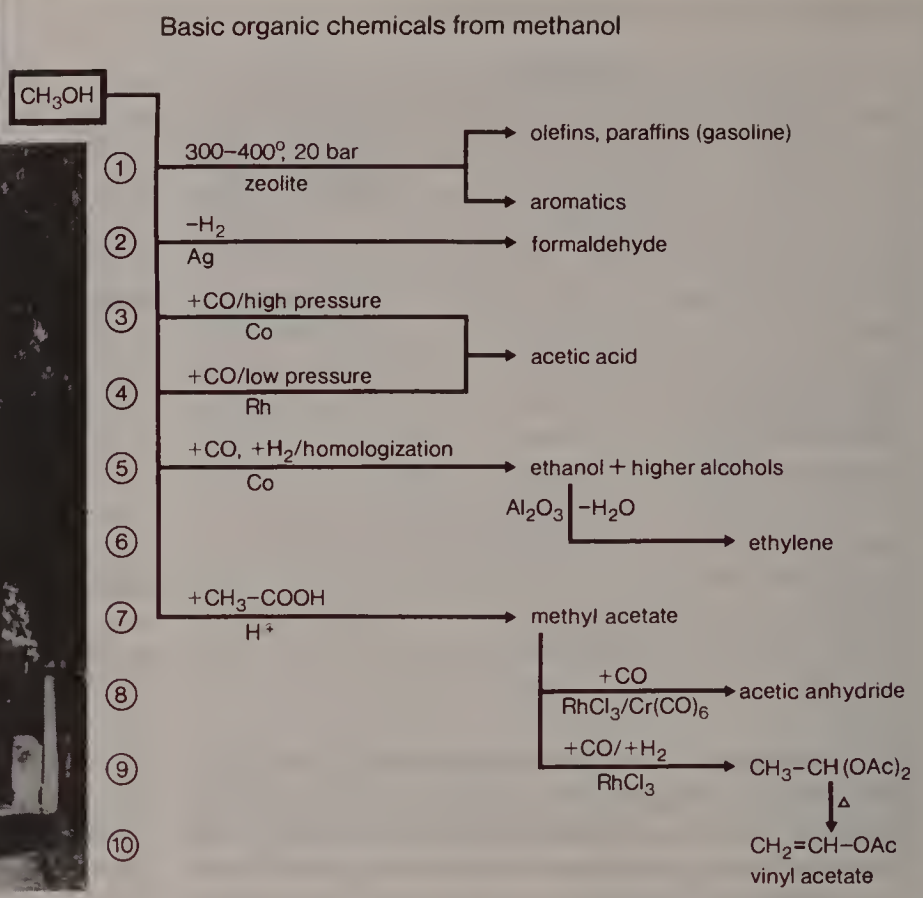
There is much discussion in Brazil about a large project for producing methanol by pyrolysis of wood. Use is to be made of the fast-growing eucalyptus tree, which is fit for felling after about 7 years. Apart from a warm climate, eucalyptus trees do not have any particularly strict site requirements.

According to a plan drawn up by the Brazilian energy supply company CESP, 65 methanol plants would be erected by 1985 (an investment of US $15 billion). Their total production of 45.4 million tons of methanol a year could probably replace about a third of Brazil's anticipated oil requirement for 1985. To reach this goal, an estimated 5.5 million hectares, 0.64% of the entire area of Brazil, will need to be cultivated with eucalyptus trees. A first 2000 ton/day methanol plant is already being built. Such plants could eventually also produce large quantities of eucalyptus oil, geraniol and other byproduct terpenoids from the leaves of eucalyptus trees.

Farming of eucalyptus trees could provide even higher yields of alcohol (methanol) per hectare than can be produced from sugar cane (ethanol). One hectare of land, it is thought, will yield about 20 tons of eucalyptus wood per year, which could be converted to about 8.3 tons of methanol. By contrast, the average yearly ethanol yield from Brazilian sugar cane is 5 tons per hectare. These estimates are based on the assumption that methanol from wood would become cheaper than fuel oil in 1982 if the price of energy continues to rise at about 15% per year. Nevertheless, it is doubtful that such a giant project to convert wood to methanol will ever be undertaken in Brazil, since the National Ethanol Programme is given greater priority.

Canada has abundant wood resources and therefore would likely produce methanol from wood. According to one study, production of methanol from wood will be more economical in Canada than methanol production from coal (by gasifying coal, and converting the synthesis gas into methanol). Both processes would require about the same investment to commercialize. The construction of 10 - 20 methanol plants (with a production capacity of 3 million tons a year) is being considered as the first phase of a massive project. The plants would initially use natural gas as a feedstock, then a combination of natural gas and wood gas, and finally gasified wood and refuse alone. It is estimated that Canadian forests could ultimately provide biomass to make 30 million tons of methanol per year, without affecting pulp supplies. In order to maintain such a programme, however, Canadian forestry authorities would have to make a radical changeover from the exploitation system to sustained yield forest management.

Large-scale, long-term plans for producing energy from biomass are also much discussed in Sweden. Swedish energy researchers believe that, by 2015, it will be possible to completely meet their country's energy requirements from renewable energy sources. Two-thirds of their renewable energy could come from biomass. Greatly enhanced yields of wood would be achieved by cultivating fast-growing varieties of willow or poplar trees, whose production of wood is said to be ten times that obtained under present forestry conditions. However, poplar trees grown in this way are vulnerable to disease and pests, and thus, large-scale biomass production will need to be combined with plant and forest protection programmes if they are to be successful.



Fast-growing trees, such as the Eucalyptus trees shown here (photo courtesy of Martzik/laender-press, Düsseldorf), could provide wood for the production of methanol. The wood would either be gasified (and the synthesis gas converted to methanol), or could produce methanol by pyrolysis. Various chemical processes could convert the methanol into ethylene, synthetic gasoline, acetic acid, formaldehyde and vinyl acetate.

Raw materials from new plant varieties

Rather than synthesizing chemical feedstocks from pyrolysis or gasification products, hydrocarbons can also be obtained *directly* from some plant species. Liquid hydrocarbons are produced by some types of euphorbia plants. Euphorbia lathyrus is a small shrub frequently used as hedges in Brazil but which could also be grown in Southern California and Australia. The shrubs need little moisture—they could be cultivated in dry regions that are unusable for foodstuff production. When the shrubs are the right height, they are cut off just above the ground. The shrubs then grow again and it is estimated that they only need to be planted new every twenty years or so.

Hydrocarbons can be separated from the latex of Euphorbia lathyrus with conventional technology. The molecular weight distribution of the hydrocarbons corresponds approximately to that of hydrocarbons in petroleum. It is therefore assumed that the raw hydrocarbon mixture could be used directly in existing refineries. According to present estimates, one barrel (159 litres) of raw hydrocarbon mixture would cost between three and ten US dollars. The American Nobel prize winner for chemistry, M. Calvin, estimates that between 10 and 50 barrels of hydrocarbons per acre could be obtained each year (4-20 tons per hectare). Higher yields might be obtainable by breeding plant varieties with higher hydrocarbon outputs. If we take a yield of 40 barrels per acre, an area the size of Arizona would be needed to provide the automobile fuel requirements of the USA. The first test farms have begun operation.

Hydrocarbons of high molecular weight are also made by some plant species. Before the first World War, 10% of the world's rubber production came from the guayule, a shrub that grows wild in dry climates. Later, the use of the guayule shrub gave way completely to the higher yielding rubber tree (Hevea brasiliensis), although the two types of rubber were of equal quality. The search for national raw material sources and the exploitation of semi-arid regions have now led to a revival in guayule research, particularly in Mexico and the USA.

In periods of rainfall, the plant forms leaves, stalks, blooms and roots; but if it is dry and cool, the "internal chemical factory" switches over to latex. This latex sometimes accounts for up to a quarter of the weight of the stalks and roots. The shrubs remain unaffected by dryness, even when no rain falls for months, or even years.

At the present time, the production of guayule rubber is not yet economical. Although the shrub can be harvested mechanically, processing of the crushed plants is rather complicated. For the process to be economically worthwhile, it is essential to utilize the by-products: wood-like bagasse (for pulp production), resins in the leaves, etc. It has been calculated that around half a million tons of guayule rubber could be harvested annually on semi-arid areas of the USA that are presently unproductive. The first test farms are already in operation, being run by rubber firms such as Goodrich.

Marine biology and aquaculture

The largest recipients and collectors of solar energy are the oceans which cover 2/3 of the earth's surface. The seas have potentially several times more useful area for agricultural purposes than the land. Yet utilization of their biomass production potential has so far been very low; it is confined essentially to fish production, which accounts for about 5-10% of the protein produced on our globe. The productivity of the seas varies enormously:

—the open sea, which covers 90% of the total ocean surface, provides less than 1% of the total fish caught,
—the coastal regions, with around 10% of the area, produce 54%, and the
—upwelling current areas, with 0.1% of the entire surface area, account for 45% of the total catch!

A microbial process, which (like the fermentation of sugar) could gain importance in the not too distant

Complex chemicals will be extracted from plants, made by microorganisms

Specialty products from biomass, made by extraction from natural products or by microbial synthesis, will not contribute decisively to the volume of organic chemical feedstocks. Nonetheless, extraction from natural sources is often a very suitable method to produce special high-quality chemicals having a complex structure. Microbial reactions with bacteria or fungi outmatch chemical synthesis in terms of their specificity, yield and low energy requirement. These biotechnological processes (which include the production of ethanol from sugar) are likely to gain importance in the densely populated industrialized countries. By developing new methods of biotechnology, mankind will be able to make greater use—and improve upon—natural synthesis of complex organic chemicals. A brilliant example of how this has been done is provided by the synthesis of penicillin antibiotics.

The highly complex structure and poor chemical stability of penicillin G—the basic substance of penicillin antibiotics—makes total chemical synthesis of this compound and modified penicillins extremely costly. Yields of penicillin G produced by the mould fungus *Penicillin chrysogenum* were at first very small: 1 - 2 mg/l. However, two basic developments made it possible to considerably raise the yield:

(1) using the many techniques offered by biology, microbiology and genetics, species of fungus were grown which could produce considerably more penicillin;
(2) the fungus was fed with phenylacetic acid, a starting material that is chemically easily accessible. This relieved the fungus of the job of making this starting material from an animo acid.

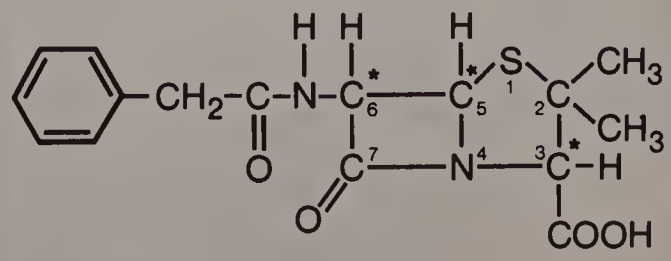
These developments enabled the yield of penicillin to be raised to 20 - 30 g/l—an increase of 20,000 times. Penicillin G has thus become easily accessible. Then arose the challenge for research to produce other, even better, penicillins. This too succeeded with the help of the fungus.

By feeding the fungus with acids other than phenylacetic acid, some may be incorporated into the penicillin molecule. For example, by using phenoxyacetic acid instead of phenylacetic acid, we get penicillin V, which is not attacked by gastric acid and can therefore be administered orally.

After major difficulties were overcome, enzymatic and chemical processes were developed to split penicillin G produced by the fungus into phenylacetic acid and 6-aminopenicillanic acid. The way was then open for the chemist to react all conceivable carboxylic acids with the 6-aminopenicillanic acid—including those which the fungus itself is unable to incorporate into the penicillin molecule. In this way, a new generation of semi-synthetic penicillins was created. They are of inestimable value to doctors as they can also be used to combat resistant pathogens.

For the production of specialty products from biomass, the synthetic chemist cannot match the high yields and specificity commonly achieved by bacteria and fungi. But, chemists *can* modify microbial action, or alter the chemical structure of the product so as to dramatically enhance its effectiveness.

Benzylpenicillin (Penicillin G)



An excellent example is provided by the penicillin antibiotics. A new generation of semi-synthetic penicillins was created after chemists learned how to cleave the phenylacetic acid group attached to the ring structure (at position 6) of the natural product, Penicillin G (shown here). They were thus able to substitute a wide range of carboxylic acids, forming antibiotics with greater effectiveness in treating bacterial infections.

future, is the production of synthetic natural gas (biogas) from marine algae. It is well-known that methane can be produced cheaply and easily from the alga *Macrocystis pyrifera* by anaerobic fermentation. This species of seaweed appears well-suited for cultivation. It is very large, grows over wide areas and can be harvested mechanically. Several harvests could be produced each year. The alga is very common in the Pacific and is also cultivated in the seas of the West Indies and in the English Channel. As with land crops, the transplantation of algae into new areas must be undertaken with caution. An algae farm of this kind could be used not only for producing energy, but also for breeding fish, crustaceans, etc.

A model marine farm—at present only a theoretical concept—is envisioned 100 miles from the Californian coast covering an area of 40,000 hectares. The primary purpose of the farm would be to produce algae and convert them into methane or methanol. It would also be used for the breeding of sea creatures such as perch and oysters, which would serve as food for man. Waste products would be used as fertilizers or animal feedstuffs.

Another aquatic plant, the water hyacinth, was once regarded only as a nuisance, but could in future prove to be a valuable source of raw materials and energy. It is the most common of all floating freshwater plants. In this century it has spread to such an enormous extent in tropical and sub-tropical waters that is has been given such names as the "blue devil", "Bengal terror" and "Florida devil". In many places it threatens to block irrigation and drainage channels and frequently hinders shipping. Its modest demands and its amazing capacity to rapidly form large amounts of biomass could well be employed to the benefit of man.

The first large-scale industrial utilization of the water hyacinth began in 1972 in Florida (USA). A company there has very successfully been processing sun-dried water hyacinths into fertilizer.

A process using water hyacinths to produce methane has been developed by NASA. The resultant biogas has a methane content of 60 - 90%. Results from existing experimental stations show that a single hectare of water hyacinths produces 0.9 - 1.8 tonnes of biomass *every day,* with an energy content equal to 230 - 460 litres of gasoline! A larger pilot plant is at present being built by NASA. It should be mentioned in passing that water hyacinths are able to store large amounts of metal salts in their roots. Tests carried out by NASA show that the water hyacinth could conceivably be used for cleaning waste water with a high salt content.

Rapid growth of the water hyacinth, the most common floating freshwater plant, could be exploited to generate large amounts of biomass. A pilot project, like the one shown in this schematic diagram, is presently being considered by NASA. Such plants could generate each day more than a ton of biomass for each hectare of water surface. When fermented, the daily yield of biogas from one hectare (containing 60 - 90% methane) would have an energy content equivalent to 230 - 460 litres of liquid hydrocarbons (*diagram courtesy of Umschau-Verlag*).

Summary and outlook

Since commercial "bioconversion" processes have not yet been developed very intensively as compared with petrochemistry, it is difficult to estimate accurately when they might become economically competitive. Despite poor prospects for rapid worldwide utilization of biomass on a large-scale (if we disregard examples like the Brazilian ethanol programme), we must nevertheless think now about developing this important raw material base for the future. Where it is economically worthwhile, we must actually set about using it.

In particular, biomass projects will likely be good investments for developing countries which (like Brazil) have favourable climate, little crude oil of their own, vast land resources, and a large potential labor force. In these countries, indigenous production of fuel and feedstocks from biomass could allow:

—a reduction in imports
—an improvement in the foreign trade balance
—greater economic independence
—creation of new jobs, as these technologies are relatively labour-intensive
—more uniform industrialization, since—unlike petrochemical plants—smaller decentralized plants are also economical
—favourable effects on employment and income in rural districts, with lower transport costs and a reduction in the migration of the rural population into the towns.

In densely populated areas such as the Federal Republic of Germany, which also has a highly developed, integrated petrochemical industry, the circumstances are different. Here too, however, people are beginning to think about making greater use of biomass—particularly from agricultural and municipal waste. In West Germany, for example, 5 million tons of surplus straw are burnt in the fields every year, generating considerable amounts of smoke with high emissions of solid matter. In 1990, it will probably be 10 million tons. The main problem facing the practical utilization of straw are its low specific weight (0.04 gm/cm^3) and the high transport costs which are involved.

Theoretically, solar energy is not a limiting factor for the future world supplies of biomass feedstocks and energy. However, it will still take some time before biomass plays a major role as a raw material and energy source. There are five main reasons for this:

—As long as the prices for fossil raw materials do not rise considerably, biomass-based energy sources and chemicals can only be competitive in exceptional cases.
—Most biomass is produced in zones with intense sun light, chiefly near the equator. Countries in these areas are often sparsely populated with poor infrastructure and/or little agricultural and technical know-how.
—Planting, harvesting and transporting crops to processing centres involve problems that do not exist with fossil raw materials.
—The plant material available at the moment is not optimized for use as a chemical raw material. This is where new lines of research are needed.
—The process from plantation to raw material is itself energy-consuming.

Summarizing, it can be stated that the speed at which mineral oil is replaced by coal, (and coal by biomass) will depend primarily on the scarcity and price of oil during the coming decades, i.e. on the economic viability of the new alternatives. The transition to these alternative energy and chemical sources will proceed at a different pace in different regions of the world (depending on factors such as trade balance, labor market, available area under agriculture and forestry, level of technology, agricultural structure and climate). We can expect the various raw material bases to co-exist alongside each other for considerable time, with constant growth in the importance of biomass.

About the author:

When he was heading Bayer's agricultural chemicals research, and as Director of Corporate Research of Bayer AG, Prof. Dr. Karl Heinz Büchel was concerned with agricultural chemicals and pharmaceuticals, especially the synthesis of new fungicides and antimycotics. Since 1977 he has been a member of the company's Board of Management, where he is responsible for Bayer's worldwide research activities.

Despite his extensive industrial experience (14 years at Bayer, and previous work at Shell International research organization), Dr. Büchel has maintained close ties with university life. He is an honorary professor at Aachen Technical University, where he has been lecturing organic chemistry since 1973. He had been assistant professor at the University of Bonn for several years after obtaining his doctorate (in 1958).

Activities outside of his company are an important part of Dr. Büchel's work. Among these are his Chairmanship of IUPAC's Committee on Chemistry & Industry, Chairmanship of the Board of Trustees of the German Chemical Information Service, and membership of the Board of Management of the Gesellschaft Deutscher Chemiker (German Chemical Society).

Professor Büchel is married, and has two children.

Mycotoxin food poisoning: an ancient and modern threat

A deepening research interest has exposed the pervasiveness of mycotoxin poisoning as the root of serious health and economic problems, both now and in the past. From this has developed a recent awareness of the global magnitude of food contamination by toxigenic fungi, a better comprehension of the mechanism of chemical carcinogenesis and a renewed interest in the metabolism of fungi and other natural product chemistry.

by Dr. Pieter S. Steyn
Council for Scientific & Industrial Research (South Africa)

From time immemorial, man and his domestic animals have suffered ill-effects from the ingestion of foodstuffs spoiled by fungi. An early reference to man's affliction by moulds is found in the Book of Amos, Chapter 4 (about 750 B.C.).

The term "mycotoxin" derives from the Greek *mykes* (fungus) and the Latin *toxicum* (poison). The term is presently used to designate fungal secondary metabolites which cause pathological abnormalities in man and warm-blooded animals. Poisoning of the host is called "mycotoxicosis" (it should not be confused with mycosis, in which mould growth in the host is involved). Mycotoxicosis can result from three types of fungi;(1) macroscopic fungi—the best known being the poisonous mushrooms, (2) parasitic fungi which grow on the maturing food plant in the field, and (3) the so-called storage fungi, which under suitable temperature and humidity conditions are capable of rapid growth during cultivation, harvest, drying, transport and storage of crops. It is these latter toxins at which this article is directed.

Extensive surveys of certain foods and animal feeds have established the global distribution of toxigenic fungi. It is difficult to specify an area or place where a mould will not grow. The importance of mycotoxins to public health and the agricultural economy, especially in countries with humid and tropical climates, is self-evident.

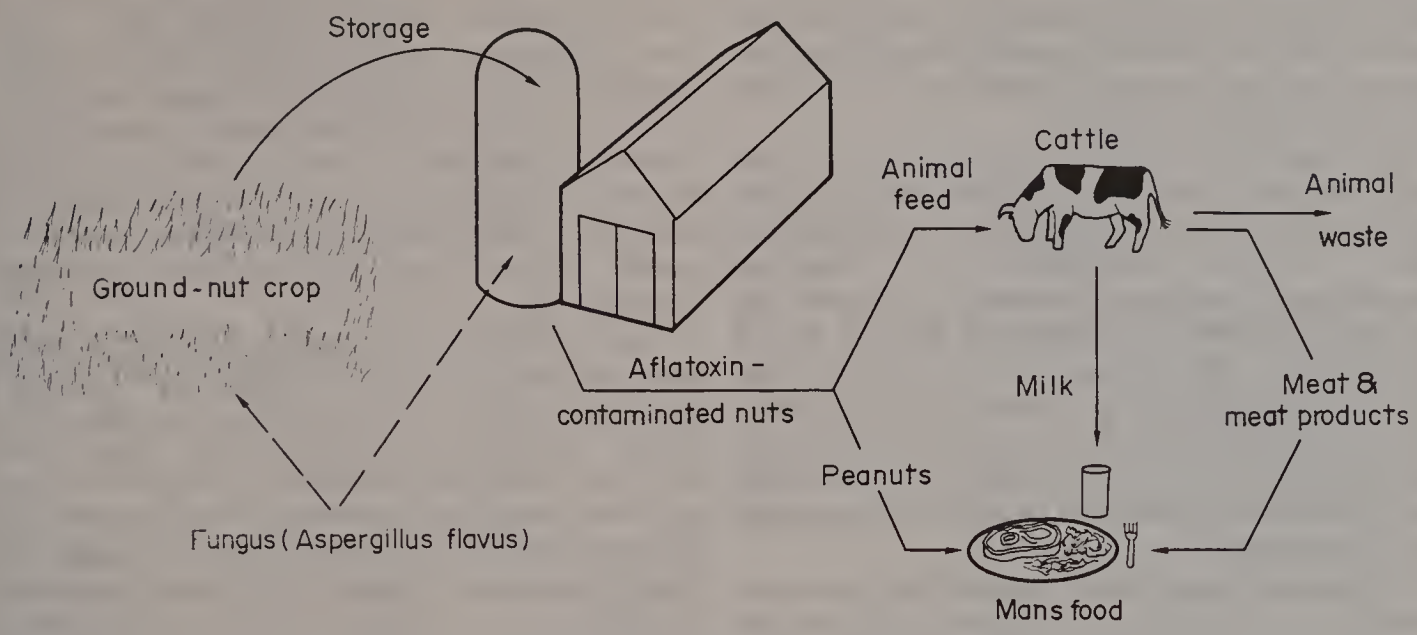
Humans may be exposed to mycotoxins in several ways; by direct consumption of toxin-contaminated foodstuffs, by consumption of residue-containing milk or meat from animals that have ingested mycotoxin-contaminated feed, and skin contact with dermally toxic compounds.

Mycotoxins have only recently received recognition as a significant class of natural toxicants in foods. As late as 1962, the pioneer mycotoxicologist Forgacs described mycotoxicoses as the neglected diseases. There is evidence for the contamination of grain crops or pasture by several mycotoxins (aflatoxins, ochratoxin A, cyclopiazonic acid, citrinin, zearalenone, patulin, penicillic acid, sterigmatocystin, PR toxin, T-2 toxin, deoxynivalenol, diacetoxyscirpenol, sporidesmin, ergot alkaloids, and tenuazonic acid). There is no common feature of chemical structure among the mycotoxins, but all have diverse and powerful pathological effects. Among these are toxicity to the liver, heart, kidneys, nervous system and skin; ability to induce cancer of the liver, mutations and hallucinations. The biological and biochemical properties of several mycotoxins require further systematic investigations.

The discovery in 1960 of Turkey-X disease, a poultry disease of then unknown origin, revived interest in the structure, synthesis and biosynthesis of mycotoxins. Within a few months of this outbreak, more than a hundred thousand turkeys and chickens died in England. The cause of the Turkey-X outbreak was traced to Brazilian peanut meal containing toxins produced by the mould *Aspergillus flavus*. Soon afterwards, the death of trout from liver cancer in Californian hatcheries was attributed to similarly contaminated feeds.

Characterization of the toxins, later given the generic name "aflatoxins", is regarded as one of the most notable accomplishments in the chemistry of natural products in recent times. To this day, aflatoxins have dominated mycotoxin research. The aflatoxins were found to be structurally related to another fungal carcinogen, sterigmatocystin. Aflatoxins contain a central coumarin unit fused to a dis-dihydrofurano unit and either a cyclopentenone or a six-membered lactone. A factor aiding all phases of aflatoxin research is their remarkable fluorescence under long wavelength ultraviolet light, thereby facilitating their analysis by thin layer chromatography. At present, subpicogram quantities of the aflatoxins can be detected by application of high pressure liquid chromatography and laser fluorimetry.

The ability to produce aflatoxins is restricted to



Aflatoxin B_1, produced by the fungus *Aspergillus flavus*, may be ingested directly by man, or may be metabolized into structurally-related toxins. Cows, for example, convert aflatoxin B_1 into the toxic compound aflatoxin M_1, which can enter man's food chain through the consumption of milk. An alternative route leading to human consumption is contaminated meat and meat products.

Aspergillus flavus and *Aspergillus parasiticus*. These organisms are distributed widely in nature. When moisture and temperature permit their growth, any foodstuff can become contaminated with their toxins. It was soon recognized that aflatoxins represented a global problem, particularly in the humid tropics. These moulds grow abundantly on most agricultural commodities—peanuts, maize, rice, cottonseed and tree nuts (pistachio and Brazil nuts), to cite a few examples, with a concommitant production of aflatoxins.

It is clear that staple foods as well as exports of most developing countries are at risk. According to some estimates, 1000 million tons of agricultural products are at risk of fungal contamination. The contribution of the peanut industry to the natural income of Niger (70%), Gambia (60%), and Senegal (30%) indicates the economic dependence of these countries on this single threatened crop. The problem of foodstuff contamination is aggravated by the ability of some strains of *Aspergillus flavus* to produce simultaneously the three mycotoxins: aflatoxin, cyclopianzonic acid and aflatrem.

Aflatoxin B_1 is the most potent liver carcinogen known, and is lethal to a wide range of animal species—including fish, birds and mammals. The International Agency for Research on Cancer regards aflatoxin as a human carcinogen. Aflatoxin is suspected of causing human liver diseases (for example, Reye's syndrome), particularly cancer in certain geographical areas (Mozambique, Swaziland, Uganda, Kenya, Taiwan, Senegal and India) based on analysis of the mycotoxin level of human foods.

Ingestion of aflatoxin-contaminated feeds by lactating cows leads to the excretion in the milk of a toxic metabolite, called "aflatoxin M_1" (derived via the benzylic hydroxylation of aflatoxin B_1). Metabolites of aflatoxin, therefore, have the potential of entering man's food chain. Contamination of milk may present a problem, especially to children. Aflatoxin M_1 can be detected in most European milk samples when highly sensitive analysis methods are used. Several studies in the Federal Republic of Germany revealed that transmission of aflatoxin into milk is directly related to their concentration in the cattle feed; a content as low as 0.25 ug of aflatoxin per kg of fodder leads to detectable levels in the milk. In Germany, nearly half the milk samples tested during the period 1972-1974 had aflatoxin M_1 levels in the range 0.05-0.33 u/L. Examination of various cheeses in 1976 revealed that most had levels of 0.02-0.23 ug/kg. These data provide impetus for strict directives on animal feed legislation, as the origin of the aflatoxins can be traced mainly to imported peanut products.

A frequently-asked question concerns the safe level of aflatoxin in the human and animal diet. The answer is that we really do not know. The usual guidelines are 5 ug/kg for foods and 10-100 ug/kg for animal feeds. These guidelines are really tolerance levels, since no carcinogen should ideally be allowed. Different animal species exhibit wide variation in their susceptibility to aflatoxins. It appears that humans have relatively low susceptibility to aflatoxin-induced cancer. An important factor determinining the vulnerability of a population appears to be its diet.

Several studies indicate that aflatoxin B_1 requires metabolic activation to exert its carcinogenic and mutagenic effects. The major route for activation proceeds through enzymatic oxidation, to yield an unstable epoxide as the ultimate carcinogen. Covalent binding of the aflatoxin B_1-oxide with the guanine residue of DNA and RNA is then likely to induce mutations.

The rigorous control of aflatoxins and other mycotoxins requires serious consideration in agricultural communities. The preferred approach is certainly to prevent toxigenic fungi from developing in foods and animal feeds. This requires improved husbandry and programs to monitor crops in the field (aflatoxin contamination of pistachio and Brazil

nuts can occur during cultivation), as well as during later handling and production stages. Analytical procedures involve sampling, sample preparation, extraction, cleanup, detection, confirmation of identity and interpretation of results.

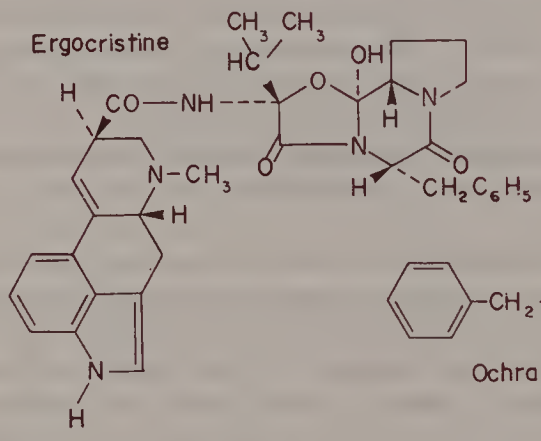
The alternative to preventing mycotoxins from developing is to destroy or to remove the toxins from agricultural produce. Considerable progress has been made on the detoxification of aflatoxin-contaminated peanuts and cottonseed. One practical application followed the discovery in Arizona of milk contaminated with aflatoxin M_1, originating from aflatoxin-contaminated cottonseed. The problem, which occurred in 1978, was solved by water-ammonia treatment of the cottonseed in huge plastic bags. Ammonia is known to induce the decomposition of aflatoxins.

The practical importance of mycotoxins stimulated research on the growth of toxigenic fungi and the biosynthesis of mycotoxins. Mycotoxins are a varied group of compounds; their only common factor is their secondary metabolic origin. These hazardous compounds are formed through a polyketide route (for example, aflatoxin and patulin), a terpene route (trichothecanes), or from amino acids (ergot toxins and sporidesmin). Particularly elegant research probed the stereospecificity of the enzyme-catalyzed reactions involved in the natural biological synthesis of the trichothecanes, ergot toxins and sporidesmin.

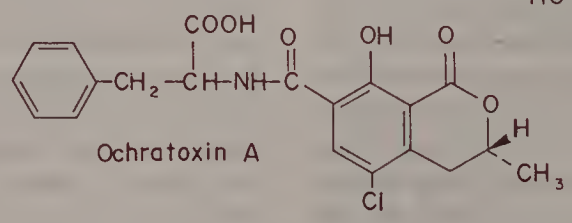
Biosynthesis of the aflatoxins received special attention. Extensive labelling studies were carried out with both radio-active and stable precursors. It was soon established that the aflatoxins are typical polyketides which are formed by linear condensation of acetyl coenzyme A with three or more units of malonyl coenzyme A. This led to the postulated biosynthetic reaction sequence for the formation of aflatoxin (from acetate, to averufin, versiconal acetate, versicolarin A, sterigmatiocystin, and finally aflatoxin B_1).

The importance and danger of mycotoxins was soon realized by the Food Chemistry Section (formerly two Commissions, now merged into one) of the IUPAC Applied Chemistry Division. Several years ago, the Commission members became actively involved in several aspects of this problem, particularly the development of internationally acceptable analytical methodology. Based on collaborative studies, methods were published for the determination of aflatoxin B_1, aflatoxin M_1 and ochratoxin A. Several international IUPAC-sponsored symposia were held in Göteborg (1972), Pulaway (1974), Paris (1976) and Lausanne (1979). In 1982 this meeting will be held in Vienna. These meetings served as an excellent forum for discussion of the various aspects of mycotoxin research (several viewpoints presented at last year's Lousanne conference were reported in Issue No. 3, 1980 of *Chemistry International*).

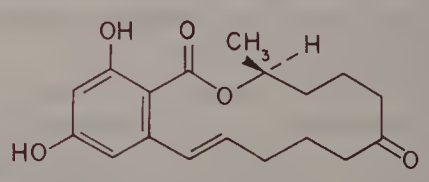
At present, the IUPAC Commission on Food Chemistry is involved in several mycotoxin-related



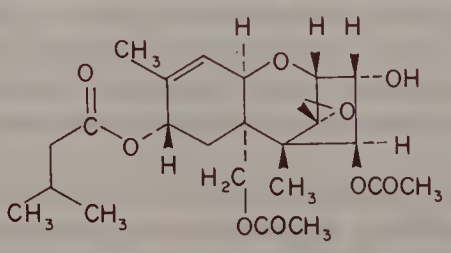
Ergocristine



Ochratoxin A



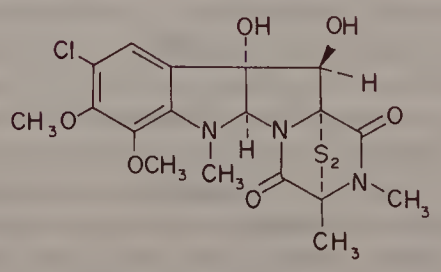
Zearalenone



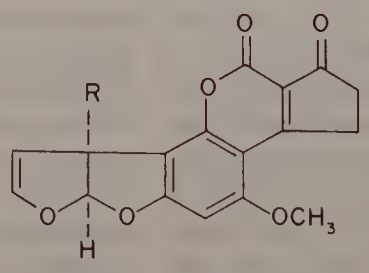
T–2 toxin

Mycotoxins are a series of compounds produced by moulds, usually during improper storage of food crops. The compounds have little structural similarity, but all exert potent physiological effects.

α – Cyclopiazonic acid

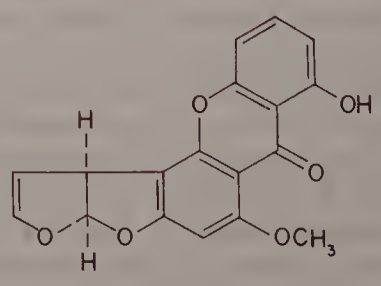


Sporidesmin



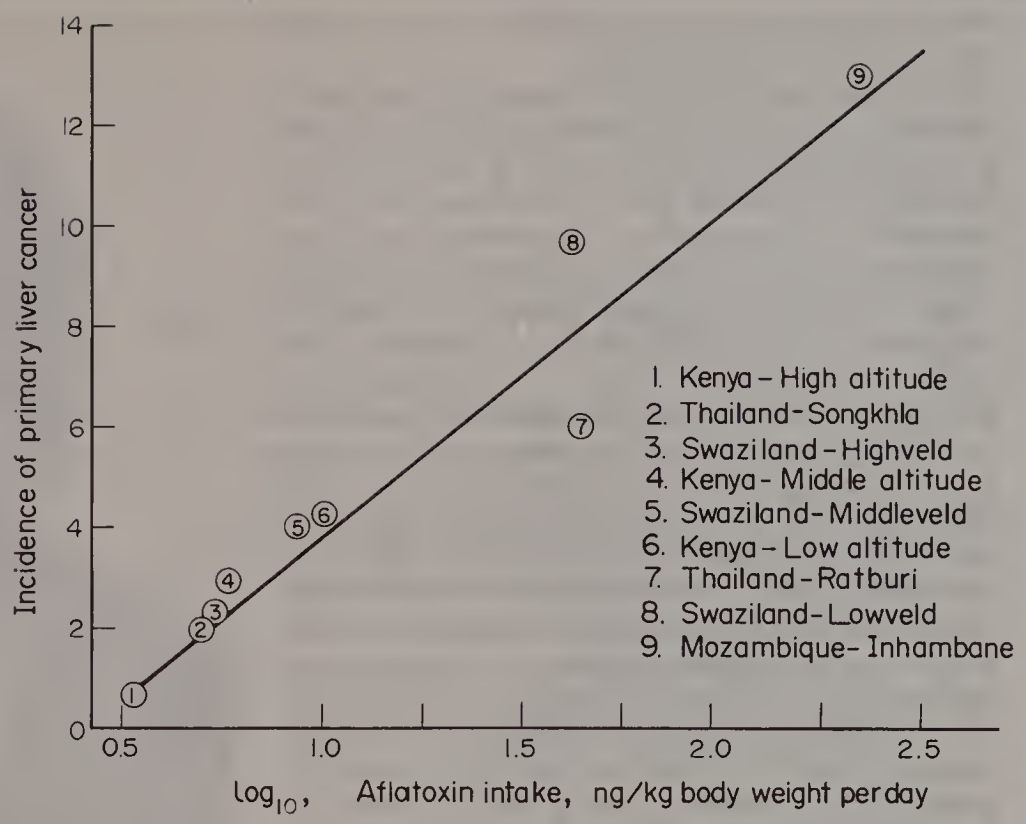
R= H Aflatoxin B_1

R= OH Aflatoxin M_1



Sterigmatocystin

A very clear correlation between mycotoxin intake and primary liver cancer is apparent from food analysis and census data of African countries. For each ten-fold increase in the average aflatoxin level in the diet, there is a constant rise in liver cancer incidence. In Mozambique and Swaziland, incidence of liver cancer was found to vary markedly amongst local groups with distinct dietary preferences, although they were living in similar environmental conditions. The highest mean intake of aflatoxins was found in the Inhambane province of Mozambique. Here, most prepared meals that were tested contained less than 0.1 mg/kg, but a small fraction (about 0.2%) contained more than 1 mg/kg.



By comparison, aflatoxin levels higher than 1.5 mg/kg have been measured in all recent cases of acute, fatal human aflatoxin poisoning. These instances characteristically occurred in populations that were nearly totally dependent on a single crop produced by themselves. Such populations are extremely vulnerable should mycotoxin contamination be favoured by unusual weather or other factors *(diagram adapted from S. J. van Rensburg's article in Mycotoxins in Human and Animal Health, 1977, Pathotex Publishers, U.S.A.).*

projects: the specification of mycotoxin analytical standards, mycotoxin residues in food of animal origin, multi-mycotoxin analysis, application of high-pressure-liquid chromatography to the analysis of mycotoxins, and decontamination procedures for mycotoxin-contaminated foodstuffs.

Mycotoxin research requires a multidisciplinary approach with contributions from epidemiologists, mycologists, chemists, biochemists, phytopath ologists, pathologists, pharmacologists and experimental toxicologists. Since the discovery of the important aflatoxin problem in the early 1960's there has been a growing interest in mycotoxins with a resulting rapid increase in the number of research articles. During the period 1969-1978, 2349 papers dealing with aflatoxin alone were cited in Chemical Abstracts.

The dreaded fungus *Claviceps purpurea* is the causal agent of ergotism (a type of severe food poisoning which can lead to permanent disability). Ergotism is caused by alkaloid toxins produced by this fungus when growing on grains and grasses. The same fungus also produces a number of toxic pigments, called the ergochromes. Two characteristic forms of the poisoning were described; gangrenous and convulsive ergotism. During the Middle Ages, innumerable epidemics of gangrenous ergotism were reported throughout Europe, but mainly in France. From feudal days, the disease has commonly been known as "St. Anthony's Fire": the holy fire (inflammation) consumes the limbs which turn black with gangrene. The most recent outbreaks occurred in Manchester, U.K. (1925) and France (1951). Convulsive ergotism is characterized by symptoms involving the nervous system.

The physiological properties of the ergot alkaloids and their derivatives led to applications in medicine and pharmacology. The first use was based on their effect on contraction of smooth muscle (such as in the uterus). The ancient Greek physician Hippocrates (460-357 B.C.) recommended powdered barley flour cooked in water to promote childbirth. In modern medicine,ergot alkaloids are widely used to block the action of the neurohormones serotonin and adrenalin. Derivatives of the ergot alkaloids also have a direct effect on the central nervous system. The derivative with the greatest effect on the mid-brain is the diethylamide derivative of lysergic acid (LSD)—a compound known to cause hallucinations in man at very low dose levels.

Certain digestive diseases in humans and animals have been linked by chemical and toxicological studies to some 12,13-epoxytrichothecane mycotoxins. An intensive study of Stachybotryotoxicosis, a disease afflicting man and horses in the Ukraine, was found to be caused by the mould *Stachybotrys atra.* The mould may frequently be found in decaying hay, straw and litter. Recent work at the American Food and Drug Administration established that the toxicity of *S. atra* was due to five macrocyclic trichothecane esters. The isolated compounds evoked the same signs of toxicity reported for Stachybotryotoxicosis.

Massive outbreaks of *Fusarium*-toxicosis occurred in Orenburg and other districts of Russia from 1942 to 1947. The disease (alimentary toxic aleukia) was found to be associated with grain (millet, wheat and barley) that had been left on the fields during winter in the war years. *Fusarium sporotrichioides,* producer of trichothecane mycotoxins such as T-2 toxin, was implicated in the disease. Recently, trichothecanes were isolated as causative agents in mouldy corn toxicosis in the Midwestern States of the U.S.A.

Trichothecanes are potent inhibitors of protein and DNA synthesis in animal cells.

Mycotoxicoses have been demonstrated mostly in domestic animals. Facial eczema (pithomytoxicosis), a photosensitization disease among sheep in New Zealand, is a typical case. This disease has been associated with ingestion of pasture grass contaminated with the mould *Pithomyces chartarum* found in decaying vegetable matter. The spores of the fungus contain the mycotoxin sporidesmin. Outbreaks of the disease follow contamination of pastures during periods of abundant spore production. Sporidesmin causes liver damage in sheep, loss of weight, jaundice and photosensitivity. The photosensitivity is caused by accumulation of a chlorophyll degradation product in the blood, due to the impaired functioning of the liver. Present aerial monitoring of spore counts allows the extent of facial eczema to be controlled. Sheep are withheld from pasture when spore counts reach a critical level. The use of fungicides to control fungal growth is another avenue of control. In New Zealand, the anthelmintic preparation "Thiabendazole", which also has fungicidal properties, was tested and found effective at extraordinarily low application rates.

A similar photosensitization syndrome occurs sporadically among sheep in the semi-desert Karoo region of South Africa. The malady, termed "yellow thickhead disease", has incapacitated more than half a million sheep during a severe outbreak. Here too, photosensitization results from impaired liver function. It seems likely that this disease is also caused by a strain of *Pithomyces.*

Ochratoxin A is a mycotoxin that was initially studied by South African scientists only as a chemical novelty. However, it is now considered an important mycotoxin on account of its biological activity (kidney and liver damage), natural occurrence, and production by various species of the fungal genera *Aspergillus* and *Penicillium.* Ochratoxin A is believed to cause liver disease among pigs in Denmark, Norway and Sweden, where it is a frequent contaminant of barley and oats. Distribution of the toxin to the kidney, liver, fat and muscle of pigs can lead to subsequent human exposure. Ochratoxin A was recently implicated as the cause of a fatal chronic kidney disease which affects people living near the Danube River and its tributaries in Bulgaria, Romania and Yugoslavia. Striking similarities were observed in kidney structure and function between human victims of the Balkan syndrome and ochratoxin-induced kidney disease in pigs. A recent survey in Yugoslavia established that ochratoxin A was most commonly present in foodstuffs (cereals and bread) in the area where the disease is prevalent.

The ochratoxin A molecule contains phenylalanine linked by an amide bond to a chlorinated dihydroisocoumarin unit. It exerts a toxic effect on bacterial and yeast cells by inhibiting protein synthesis. The mycotoxin competes with phenylalanine in the synthesis of RNA. In fact, inhibition of protein synthesis by ochratoxin A can be completely overcome in bacteria by adding phenylalanine to the cell culture medium. Indeed, experiments with laboratory animals have shown that the toxic effects of ochratoxin A can be prevented by administration of phenylalanine.

About the author:

Pieter S. Steyn is presently Senior Chief Research Officer at the National Chemical Laboratory in Pretoria, South Africa. He has been a member of the former IUPAC Commission on Food Contaminants since 1973, and is now a titular member of the newly-formed IUPAC Commission on Food Chemistry.

His research interests are related to the isolation, structure elucidation and biosynthesis of mycotoxins. These investigations started in 1964 and included studies on the ochratoxins, aflatoxins, secalonic acids, novel dioxopiperazines, anthraquinonoid mycotoxins and trichothecenes.

For more information:

The most recent references recommended by the author for those wishing to obtain more background information are:

The Biosynthesis of Mycotoxins—A Study in Secondary Metabolism. P. S. Steyn (ed.), Academic Press, New York, 1980.

Aflatoxins: Chemical and Biological Aspects. J. G. Heathcote and J. R. Hibbert, Elsevier Scientific, New York, 1978.

Toxicology—Biochemistry and Pathology of Mycotoxins. K. Uraguchi and M. Yamazake (eds.), Halsted Press, Kodansha Ltd, Tokyo, 1978.

Mycotoxic Fungi, Mycotoxins, Mycotoxicoses, Volumes 1,2 & 3. T. D. Wyllie and L. G. Morehouse (eds.), Marcel Dekker, New York, 1977-78.

A novel approach to the control of mycotoxins is breeding for resistance: e.g. resistance of the plant to spoilage by bacteria and attack by moulds, or resistance of livestock to toxins. This goal has already been partially achieved in some areas. Most of the cereal varieties currently cultivated are relatively resistant to the *Claviceps* species causing ergotism.

Nitrosamines as a human hazard

It has now been shown conclusively that nitrosamines *can* cause cancer. But whether these chemical compounds, commonly present in our food and environment at minute concentrations, actually *do* is the focus of an intense international controversy. Are nitrosamine precursors put into the environment by man more dangerous than the miniscule amounts formed naturally in the body? And what is the role of non-volatile nitrosamines, which because of difficulties with their measurement, are completely ignored in nearly all studies? These questions remain to be answered before we know if governments are over-reacting, or moving too hesitantly, in the steps they are taking to protect consumers from nitrosamines: the "carginogens in search of a cancer".

by Ernest Walker
International Agency for Research on Cancer

Since 1956, when nitrosodimethylamine (NDMA) was shown to cause cancer in animals, national health authorities have been confronted with an important problem. Does a carcinogenic risk arise from widespread use of nitrite in food processing? Concern with this question was heightened by the observation in Norway of severe liver damage in sheep fed a diet of fishmeal preserved with nitrite. NDMA was identified as the toxic agent, and had apparently been formed from nitrite and secondary amines in the food. Subsequent testing of 67 different N-nitroso compounds revealed that most were carcinogenic. These nitroso compounds were found to produce tumours in particular organs independently of the route of administration.

In view of the growing importance attached to nitrosamines, a Working Group was set up in 1969 by the International Agency for Research on Cancer (IARC). The group, which included interested members of IUPAC, considered the analysis of nitrosamines in food and related problems. Two essential conclusions emerged. Firstly, analytical methods were needed to determine nitrosamines in the range of 1-10 parts-per-billion. Secondly, it was clear that a good deal more development work would be required to meet this objective, even for volatile nitrosamines.

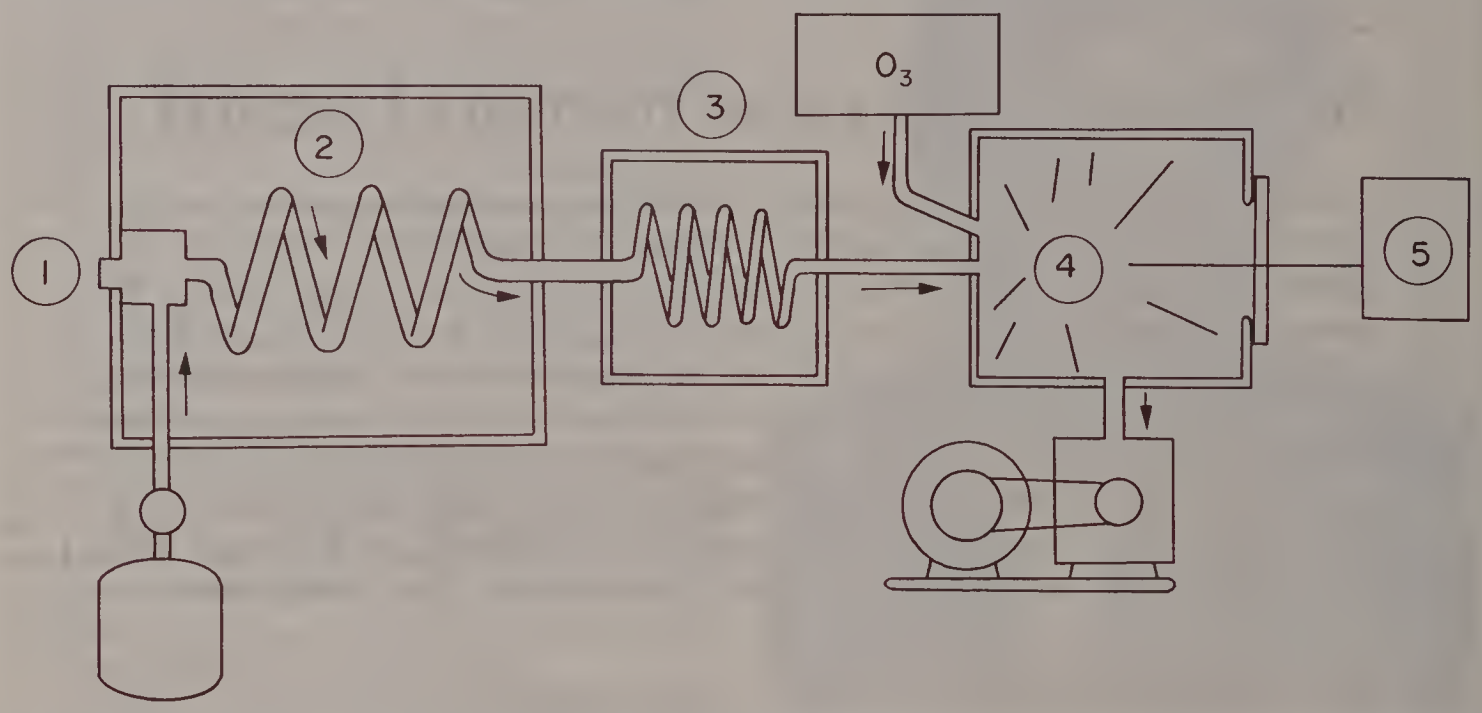
The distinction of volatile (able to be steam distilled) and non-volatile nitrosamines was a convenient definition which allowed attention to be focussed on one specific group of compounds. Volatile nitrosamines include all short-chain dialkylnitrosamines and certain cyclic nitrosamines (such as nitrosopiperidine, nitrosomorpholine and nitrosopyrrolidine) which are known to be carcinogenic. Non-volatile nitrosamines are an ill-defined array of nitroso compounds (including various nitrosamides and even nitrosated protein and polypeptides), and were considered a separate problem beyond the scope of the meeting. Even today, non-volatile nitrosamines remain a little-explored and elusive problem.

Following the next working conference held at Heidelberg (1971), it was evident that sufficient progress had been made to initiate joint IUPAC/IARC collaborative studies. These would compare analytical methods, with the objective of selecting the most suitable for further study.

The advent of the Thermal Energy Analyzer (TEA) brought a new dimension to nitrosamine analysis. The technique is highly selective to nitrosamines and does not require time-consuming clean-up procedures. False responses (a positive indication of nitrosamines, when none are actually present) are possible, but these have been very rare in practice. The cost of the instrumentation is higher than with conventional gas chromatography detection, although this is offset by the practicality of the method. As a result, TEA detection has now become responsible for the bulk of current environmental data.

The principle of operation of the TEA detector is simple. The effluent from a gas chromatography column is introduced into a catalytic furnace maintained at about 450°C. Here, the relatively weak N - N bond

The Thermal Energy Analyzer provides a sensitive and specific method for the detection of trace amounts of nitrosamines. The sample, contained in a suitable solvent, is initially injected (1) and separated into components (2) in a gas chromatograph or by high-pressure liquid chromatography. Upon exciting the chromatograph, nitrosamine compounds are suddenly vaporized by high heat (3), causing the weak N - NO bond to rupture, and releasing the stable nitrosyl radical, NO. The temperature required to break down nitrosamine compounds is reduced by utilizing a catalyst.



Subsequent reaction of the NO radical with ozone (4) produces excited NO_2 molecules, which emit their excess energy as infrared radiation. After passing through a filter, the radiation is detected by a photomultiplier (5). Although the Thermal Energy Analyzer will respond to all nitrosamines, it is "blind" to virtually all other compounds.

of the nitroso group (N - N = O) is cleaved, with stoichiometric formation of nitric oxide (NO). A cold trap (at about -150°C) then removes virtually all material except the helium or oxygen carrier gas and the NO, which is finally detected in a selective chemiluminescence system. In principle, the detector responds only to compounds producing NO in the catalytic furnace.

A critical comparison of TEA, mass spectroscopy and gas chromatography detection was conducted by IARC and IUPAC. The chromatographic methods included direct detection by alkali flame ionization and electrolytic conductivity, as well as electron capture detection after conversion of nitrosamines to nitramine or heptafluorobutaryl derivatives. In measurements of four N-nitrosamines in a heavily-spiced luncheon meat, the standard deviation between TEA analysis results was almost always less (as little as one-fourth) that obtained by gas chromatography or mass spectroscopy. Only in one case (measurement of nitrosodiethylamine with MS) could an alternative method provide a slightly lower standard deviation of results.

There is no doubt that some early analytical work with nitrosamines was naive and the data unreliable. However, the quality of published data has improved since about 1970, when better techniques became widely used and the problems of isolating and measuring a few ppb of nitrosamines were better understood. Thus, much of the data collected on environmental occurrence in the IARC risk evaluation of nitrosamines (IARC Monograph 17) was confirmed by mass spectrometry. From this study, it was evident that the main analytical priorities have been nitrosamine measurements on meat and fish, followed by cheese. Other types of food have been analyzed less frequently, but with few exceptions, volatile nitrosamines are found not to be present.

Analysis of nearly 200 varieties of food typical of a United Kingdom diet showed that the nitrosamine intake consists essentially of NDMA, with an average daily intake of about one microgram per week, and NPyr (nitrosopyrrolidine) at about 3 microgram per week. The principal source of these nitrosamines was processed meat with a smaller contribution from fish and cheese. Vegetables and other food staples contributed little or no volatile nitrosamines to the diet.

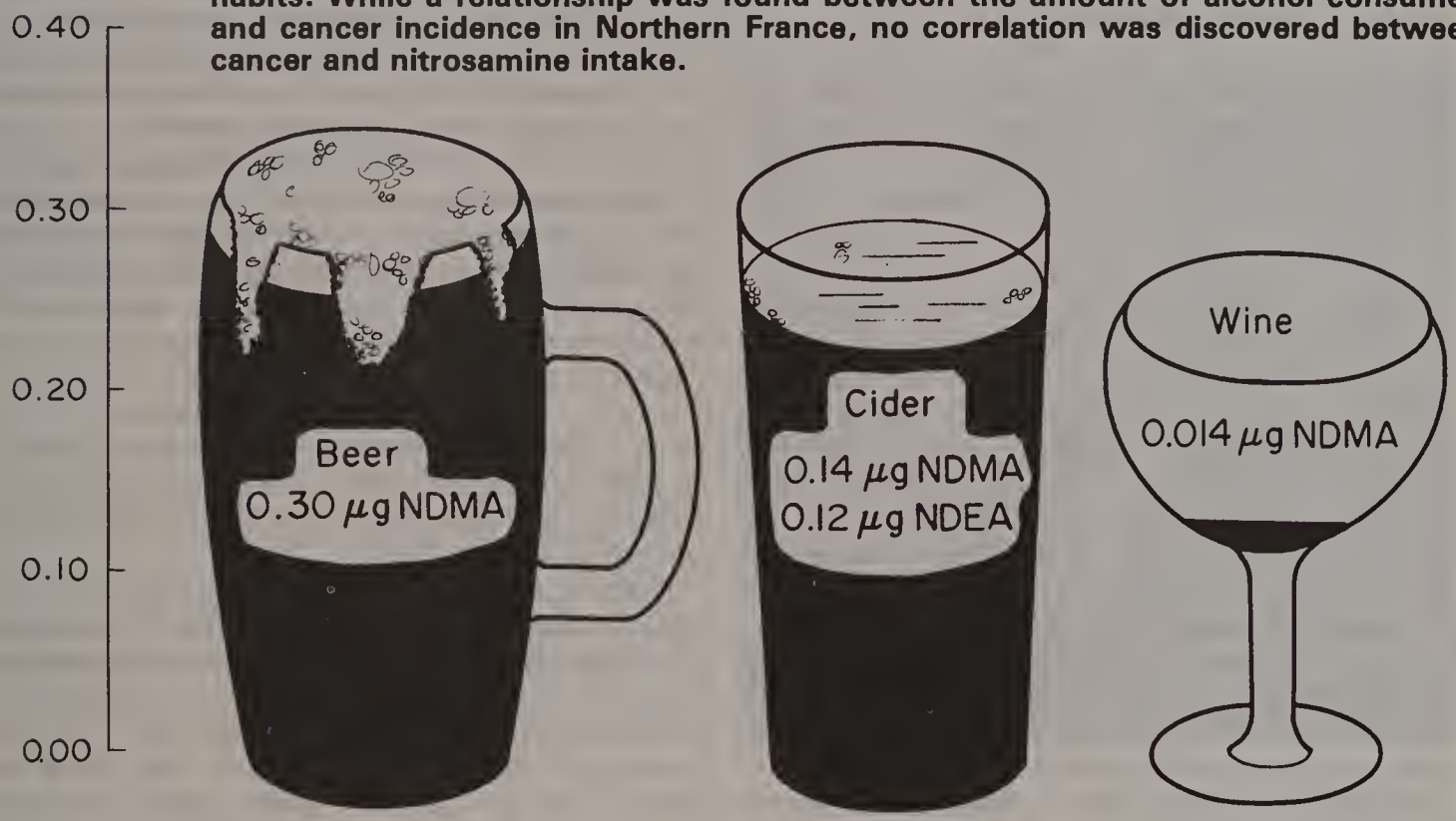
An extensive survey of volatile nitrosamines in the diet in the Federal Republic of Germany, based on over 3000 samples, indicated similar nitrosamine intake to that in the United Kingdom. A general overview of the literature suggests that this would be the case in other communities with the same type of diet.

A characteristic of many nitrosamines is their propensity to produce oesophageal cancer. Yet in a region of Iran along the Caspian Sea, where this disease is reported to have the highest incidence in the world, a dietary survey showed little evidence of volatile nitrosamines above the 1 ppb level. Nitrosamine intake of the local population is probably even lower here than in either the United Kingdom or Germany, where nitrosamine levels in the diet are generally less than 10 ppb. Evidently, oesophageal cancer can commonly occur *without* high levels of volatile nitrosamines. Concentrations

Intake of volatile nitrosamines (μg) from alcohol consumption

The intake of volatile nitrosamines from alcoholic beverages depends very much on the type of beverage consumed. A beer drinker who imbibes 40-80 grams of alcohol each day can expect, on average, to ingest twenty times the total amount of NDMA as a wine drinker with the same alcohol intake. In fact, one study showed that German beer drinkers ingest ten times as much NDMA from their beer as they obtain from their food.

However, other factors should be considered before you change your drinking habits. While a relationship was found between the amount of alcohol consumed and cancer incidence in Northern France, no correlation was discovered between cancer and nitrosamine intake.



of non-volatile nitrosamines in the diet of Iranians living in the Caspian littoral were not determined, since suitable analytical methods were lacking. Here remains, as in other surveys, an important gap in our knowledge.

The food commodity which is probably the most extensively studied is bacon. During controlled experimental cooking, the nitrosamine content of bacon tends to increase, depending upon the cooking temperature and nitrite content of the meat. A major proportion of the NDMA and NPyr passes into the vapour, so that the delicious odour of frying bacon represents—in principle—an increased carcinogenic risk for the cook. Efforts to monitor nitrosamines resulted in one encouraging finding, reported at an IARC Working Conference in 1978. A recent decline in nitrosopyrrolidine levels in bacon was observed, apparently resulting from changes in the manufacturing process which were introduced to inhibit nitrosamine formation.

The presence of nitrosopiperidine (NPip) in certain meat products (such as frankfurters and other sausages) has been shown to be caused by the addition of premixed spices containing nitrite. The NPip was probably formed by the interaction with pepper constituents such as piperine. As a result, the use of premixed spices has been discontinued in many countries, and specifically banned in Canada and the United States.

Recent concern has focussed on beer as a source of NDMA in the diet. The first extensive study, made in the Federal Republic of Germany, showed an average nitrosamine level of 2.5 μg/L (ppb). Other studies have now shown that this value is fairly typical of beer in many countries. While nitrosamine levels of beer are similar to those in processed meat, the quantities consumed are not. An average man's intake of NDMA from beer in the German Federal Republic is nearly ten times as much as the amount he ingests from food. Drinking alcohol (like smoking) is recognized by epidemiologists to be a carcinogenic risk. Smoking certainly involves the intake of nitrosamines; and drinking alcoholic beverages is likely to be an important source, unless your tipple is restricted to wine (which does not contain significant amounts of volatile nitrosamines). However, do these minute doses of nitrosamines, taken over an extended period, represent a carcinogenic risk?

One attempt to find an answer was a long-term study on oesophageal cancer in northern France. It established that there was indeed a correlation between cancer incidence and the amount of alcohol consumed. Furthermore, the study discovered an apparent synergistic effect between tobacco use and alcohol consumption.

To test the hypothesis that nitrosamines might be involved as a cause of oesophageal cancer, many types of alcoholic drinks were analyzed, with particular emphasis on those consumed in the study area. Using data for the amounts of different beverages consumed in the area, the average daily intake of nitrosamines was calculated. The principal contributor to nitrosamine consumption was found to be beer, whereas cancer incidence is more closely

associated with consumption of the popular locally-produced apple brandy and cider. The absence of correlation is not in itself conclusive, and in spite of the ambiguous study results, positive efforts are being made to decrease nitrosamine levels in beer. The high nitrosamine content of beer is now known to be caused by nitrogen oxides in the hot gases used to dry the malt. NO_x-containing combustion gases are allowed to come into direct contact with the malt, and apparently react with amine constituents of the malt. By introducing sulfur dioxide into the hot burner gases, levels of nitrosating agents have successfully been reduced. An alternative is to use indirect heating, although this is considerably more expensive.

Food and drink cannot be considered in isolation as a source of nitrosamines. Some drugs can undergo nitrosation reactions, and are a potential source. Of these, the most widely investigated has been the analgesic amidopyrine, a tertiary amine. It reacts with nitrosating agents to produce NDMA, which has been found in many drugs purchased over the counter in a number of countries. NDMA might also be formed by nitrosation of oxytetracycline, dextropropoxyphene, chlorpromazine, clorpheniramine, methadone and methyapyrilene. The drug disulfiram, which has been used to control alcoholism, gives NDEA (nitrosodiethylamine), as may quinacrine and lucanthone.

Smoking has already been mentioned as a source of nitrosamines. Extensive work in the United States and in the Federal Republic of Germany indicate levels of up to 100 ng/cigarette of NDMA, NDEA and NPyr in smoke condensates. Tobacco-specific nitrosamines, such as the respiratory carcinogen nitrosonornicotine, have also been found at levels exceeding 200 ng/cigarette.

Workers in some industries are also subject to increased nitrosamine exposure. NDMA has been found in working atmospheres in the tanning industry at levels of up to 50 ppb, nitrosomorpholine is encountered in the rubber industry and nitrosodiethanolamine in cutting fluids used for metal turning (and in cosmetics). In herbicides formulated with secondary amines, the corresponding nitrosamines have been found.

An important aspect of N-nitrosocompounds, which must be considered in assessing human exposure, is that they can be formed in the body (*in vivo*). Nitrite is formed by bacterial reduction of nitrate in the gastro-intestinal tract or saliva. It can react with nitrosatable amines present in food or formed during digestive processes.

That nitrosamines can be formed in the human digestive tract was first demonstrated in 1968 by the formation of the non-carcinogenic nitrosodiphenylamine from its precursors. It is presently suspected that nitrosamines are formed *in vivo* at levels of about 2 ppb. If this is confirmed, then the intake of volatile nitrosamines from the diet and environment may be comparable with the amount synthesized *in vivo*.

Volatile nitrosamines may, of course, represent only one component of the total N-nitroso compounds formed. Current research shows that the nucleic acid methyl adenosine (which may be present in foodstuff and in cell and bacterial debris in the gut) readily forms methylnitrosoadenosine, a compound that is carcinogenic in mice. Polypeptides also appear to form nitrosated compounds, although whether these are carcinogenic is not yet known.

Complicating this situation even further, we must also consider the inhibition or catalysis of nitrosation by other substituents, present naturally or as additives in food and drink. The inhibiting effect of natural phenols present in apple juice was discovered first. It was later demonstrated that phenols compete with amines for available nitrite, and thus inhibit nitrosamine formation. Subsequently, ascorbic acid was shown to be an even better inhibitor and, in fact, ascorbates are widely used as inhibitors in meat processing (α-tocopherol has also been shown to be effective). Because of their ability to scavenge nitrite, ascorbic acid and sulphamic acid are now commonly used to avoid inadvertent nitrosation during chemical analysis of nitrosamines.

Phenols, as well as acting as inhibitors, also promote nitrosation through the formation of C-nitrosophenol catalysts. A number of naturally-occurring polyphenols can function in this way. Catechin is a good example of this type of compound. Thus, the amount of nitrosamines formed *in vivo* could be highly dependent on the phenol/nitrite balance. However, not all phenolic compounds act as promoters. Chlorogenic and gallic acids were first thought to be promoters, but are now known to affect nitrosamine formation only in the presence of alkali.

Anions can promote nitrosamine formation. One of the most effective is thiocyanate, which is present at higher levels in the saliva of smokers than non-smokers.

Bearing in mind the difficulties in assessing the role of nitrosamines at low levels, it is not surprising that Sir Richard Doll described them as "carcinogens in search of a cancer"! Since cancer usually requires a long period to develop, there are—quite understandably—diverse views on whether or not minute amounts of nitrosamines constitute a carcinogenic hazard. This uncertainty also provides legislative problems. On the one hand is the possible carcinogenic risk of nitrosamines. Against this must be weighed the benefit of nitrite/nitrate preservation, which is an economic and effective means of controlling the known hazard of food spoilage by the bacteria *Clostridium botulinum*.

In most countries, a compromise position has been taken by monitoring residual nitrite and nitrate levels more closely than in the past. A practical approach is applied by the Department of Agriculture in the United States. They established in 1978 a 10 ppb limit for confirmation by mass spectrometry as the maximum amount of volatile nitrosamines allowed in bacon after preparation for eating. Provision was made at that time to reduce the limit to 5 ppb in 1979.

Also in 1979, the US Food and Drug Administration introduced a 5 ppb limit for nitrosamines in beer. The United States is apparently the only country which has, so far, introduced a statutory limit for nitrosamines. The only other country taking similar action is the Federal Republic of Germany, in which a limit of 0.5 ppb is being considered.

There are obviously problems in setting limits for nitrosamines. The responsibility to protect the consumer must be evaluated and weighed against the cost of reducing nitrosamine exposure. The practical approach of the United States is workable at the moment, but what would be the effect if tomorrow the reliable limit of detection could be reduced a hundred-fold? Perhaps we could use the levels that our bodies naturally generate *in vivo* as a guide, assuming of course, that we can continue to overlook the possible effects of non-volatile nitroso compounds!

About the author:
Mr. Walker, a member of the IUPAC Commission on Food Chemistry, works in the Programme of Environmental Carcinogens of the World Health Organization's International Agency for Research on Cancer (Division of Chemical & Biological Carcinogenesis) in Lyon, France.

Previously a Principal Scientific Officer in charge of an analytical methods research section at the Laboratory of the Government Chemist, Mr. Walker was seconded to IARC in 1970 to set up a chemistry laboratory and train staff for trace analysis of environmental carcinogens. His interest in cancer research and coordination of chemical analysis with epidemiology led him to stay at IARC until his retirement in June this year at age 60, when he returns to the UK.

A graduate of the University of London, Mr. Walker served as a member of the Executive Committee of the Chromatography Discussion Group and as Chemistry Rapporteur to various international IARC Committees evaluating the carcinogenecity of chemicals. He has been a Fellow of the Royal Institute of Chemistry since 1970.

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

TOXICOLOGY

March 4 - 7. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142 - 144 Oxford Road, Cowley, Oxford OX4 2DZ, UK)

PARTICLE INTERACTIONS IN COLLOIDS

March 16 - 21. Int'l Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

MÖSSBAUER EFFECT

April 13 - 17. Int. Conference on the Application of the Mossbauer Effect. Srinagar, India.
(Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi, 110012, India)

SURFACE AND COLLOID SCIENCE

July 5 - 10. 4th Int'l Conference on Surface and Colloid Science, Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Israel-Jerusalem)

MACROMOLECULAR

July 6 - 9. 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, ler Étage, Université Pierre et Marie Curie, 4 Place Jussieu, F-75230 Paris Cedex 05, France)

POLYMER CHARACTERIZATION

July 13 - 17. Int'l Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

CHARACTERIZATION OF POLYMERS BY NMR

July 20 - 23. 22nd Prague Microsymposium on Characterization of Dynamic and Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Heyrovského n.2, CS-162 06 Praha 616, Czechoslovakia)

CAROTENOIDS

July 26 - 31. 6th Int'l Symposium on Carotenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, POB 147, Liverpool L69 2BX, UK)

ORGANOMETALLIC CHEMISTRY

August 2-6. Int'l Symposium on Organometallic Chemistry Directed to Organic Syntheses. Fort Collins, USA.
(Dr. L. S. Hegedus, Dept. of Chemistry, Colorado State University, Fort Collins, Colorado 80523, USA)

CHEMICAL EDUCATION

August 9 - 14. 6th Int. Conference on Chemical Education. Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, USA)

ORGANOMETALLIC CHEMISTRY

August 9 - 14. 10th Int'l Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

IUPAC CONGRESS

August 16 - 22. 28th IUPAC Congress. Topics are: Chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, physical chemistry, inorganic chemistry, and organic chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada, 151 Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

ANALYTICAL STUDIES

August 20 - 21. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford Street, London SE1 9NQ, UK)

DRUG RESEARCH

August 25 - 28. Int. Symposium on Stratergy in Drug Research. Noordwijkerhout, The Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B. V. POB 2, 1380 AA Weesp, The Netherlands)

AROMATIC COMPOUNDS

Aug. 30 - Sept. 4. 4th Int'l Symposium on Chemistry of Novel Aromatic Compounds, Jerusalem, Israel.
(Prof. I. Agranat, Dept. of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel).

CHEMICAL PHYSICS

October 1 - 7. Int'l Symposium on Chemical Physics. Moscow/Yerevan, USSR.
(Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2 - 6, SU-117334 Moscow, USSR)

1982

CHEMISTRY RELATING TO AGRICULTURE
February 2 - 5. Chemical Research to Meet the World's Expanding Food Needs (CHEMRAWN 11) Manila, Philippines.
(Dr. Charles S. Dennison, Executive Director, Council on Science & Technology for Development, 2010 Massachusetts Avenue NW, Washington D.C. 20036, USA)

THE SAFE USE OF SOLVENTS
March 23 - 27. The Safe Use of Solvents. Brighton, UK.
(Mr. S. G. Luxon (Chairman), Health & Safety Executive, 25 Chapel Street, London NW1 4DT, UK)

TRENDS IN PHYSICAL ORGANIC CHEMISTRY
July 11 - 16. 6th IUPAC Conf. on Physical Organic Chemistry. Louvain-la-Neuve, Belgium.
(Prof. A. Bruylants, Université Catholigue de Louvain, Laboratoire de Chimie Generale et Organique, Bâtiment Lavoisier 1 Place Louis Pasteur, 1348 Louvain-la-Neuve, Belgium)

MACROMOLECULES
July 12 - 16. IUPAC Macromolecular Symposium. Amherst/Mass. USA.
(James C. W. Chien, Dept. of Polymer Science & Engineering, University of Massachusetts, Amherst, Massachusetts 01003, USA)

NATURAL PRODUCTS
August 2 - 7. 13th Int. Symposium on Chemistry of Natural Products. Pretoria, S.A.
(Mrs. Jeanne Beck, Symposium Secretariat—S.219, CSIR, POB 395, Pretoria 0001, Republic of South Africa)

POLYMERIZATION OF HETEROCYCLES
Summer Int'l Symposium on Polymerization of Small Heterocycles and Aldehydes. Poland.
(Prof. Z. Jedlinski, Polish Academy of Sciences, Polymer Institute, POB 49, Curie-Sklodowskiej 34, PL-41 800 Zabrze, Poland)

MYCOTOXINS AND PHYCOTOXINS
Aug. 31 - Sept. 2. 5th. Int. IUPAC Symposium on Mycotoxins and Phycotoxins. Vienna, Austria. (Prof. Palle Krogh, Head, Department of Microbiology, Royal Dental College, Juliane Mariesvej 302 DK-2100 Copenhagen O, Denmark)

RECENT REPORTS

Glycerine: Standard methods for the analysis of oils, fats and derivatives (6th edition, 1st supplement: Part 2 (1980) Section III). Prepared by A. Hautfenne. *Pure & Appl. Chem,* 52, No. 7 (July 1980) pp. 1941 - 1954.

Sub-primary particles in PVC: Identification and elucidation of their role during flow. Prepared by F. N. Cogswell. *Pure & Appl. Chem.,* 52, No. 8 (August 1980) pp. 2033 - 2050.

OFF THE PRESS

Recent IUPAC publications

Thermodynamic and transport Properties of Organic Salts

This book examines thermodynamic and transport properties of salts with organic anions and/or cations in a variety of states: as pure salts, salt mixtures, molten salts, liquid crystals and in solution. Phase diagrams are included where appropriate and Appendices provide additional information on structure and electrochemical studies. The editors, Prof. P. Franzosini and M. Sanesi, have achieved a good balance between presentation of physicochemical data and descriptive reviews of the subject.

This 27th volume of the IUPAC Chemical Data Series is scheduled for publication in October. It will contain about 380 pages, and will be available at a price of £40, or approximately US$90.

Boron Chemistry—4

One plenary lecture and 12 session lectures presented at the 4th International Meeting on Boron Chemistry (held July 1979 in Utah, USA) are contained in this volume of the IUPAC Symposium Series. The plenary lecturer, Professor William Lipscomb, has received a Nobel prize for work on boron chemistry and his lecture provides a knowledgeable perspective on this important field. Session lectures present results of recent research on the synthesis, reactions and structures of new and interesting boron compounds. Several papers illustrate the recent merging of classical boron hydride chemistry with organometallic chemistry. Other areas covered are nonclassical ions, medical applications of boron analogues of amino acids, and the use of boron compounds in organic synthesis.

The 168 page hardcover edition, edited by Prof. Robert Parry and Goji Kodama, is expected to be available in October at a cost of £22, or about US$49.50.

Coordination Chemistry—20

At the 20th International Conference on Coordination Chemistry held in Calcutta (10 - 14 December 1979), many of the world's leading chemists discussed their most recent research on the synthesis and structure of organometallic compounds and their applications in biochemistry, agricultural chemistry, organic chemistry and catalysis. This volume contains 26 invited lectures presented at that conference. Of particular interest are papers on synthetic oxygen carriers, metal chelates as anti-cancer agents, nitrogen fixation, stereochemistry of coordination compounds, insertion reactions and mimicry of metalloenzymes.

Edited by Prof. D. Banerjea, this hardcover volume contains about 286 pages and more than 850 references. Scheduled for publication in November/December, it will be available for £34, or about US$75.

Understanding drugs, testing oils & fats and fond memories of a thermodynamicist

Recent advances in the understanding of drug receptors are briefly reviewed in the 21st Newsletter of the IUPAC Commission on Medicinal Chemistry. Prof. Adrien Albert (who authored the article "The Molecular Basis of Drug Action" in *Chemistry International,* No. 3, 1980) points out that the concept of the drug receptor has undergone steady development since it was first postulated in 1878. Then, Langley advanced the idea that natural transmitter substances are recognized by cell "receptors", inducing a biological reaction. Man-made drugs function by mimicing the molecular shape of natural transmitter substances, either exciting the receptor or blocking its response to the natural transmitter. Undoubtedly, the best-known receptor is the one which propagates nerve impulses in vertebrate animals and man. This receptor, stimulated by acetylcholine released at the nerve junction, is the one on which researchers (and Prof. Albert in his brief review), have focussed their attention.

Study of the acetylcholine receptor has been greatly aided by its extraction. Electric tissue of two fish species provide a source of abundant and homogenous nerve synapses. By homogenizing and centrifuging the tissue, medical researchers are able to produce a fraction containing up to 40% of receptor protein bound to cholesterol and lipids. From this, the actual receptor protein can be isolated by straightforward experimental techniques.

The receptor protein turns out to be a glycoprotein of 40,000 molecular weight. Several sugar units (glucose, lactose and mannose) are attached to the protein structure.

Curiously, the receptor proteins can be incorporated into artificial lipid membranes that have properties almost identical with the natural one. These membranes, which can be made with lipids derived from soya beans, regulate the flow of sodium ions as do natural nerve cell membranes. The artificial membranes also bind agonist and antagonist drugs which mimic the configuration of acetylcholine.

In addition to the review "The Acetylcholine Receptor", the Newsletter contains features specifically of interest to medicinal chemists. It provides a listing of 84 forthcoming conferences related to medicinal chemistry, books recently published dealing with medicinal chemistry, and topics to be discussed at the IUPAC-sponsored symposium on the "Strategy of Drug Research" (25 - 28 August 1981)—as well as news from the Commission on Medicinal Chemistry and corresponding organizations. The newsletter is edited by Commission member Dr. Frank Clarke (Pharmaceuticals Division, Ciba-Geigy Corporation, Ardsley, New York 10502, USA), from whom copies of future newsletters may be requested.

A First Supplement has now been published to the 1979 edition of "Standard methods for the analysis of oils, fats and derivatives"*. The new edition provides updated tests (the previous edition was published in 1964) for evaluating vegetable oils, margarine and similar food products. These commodities comprise an essential part of international trade, and standard test methods ensure that consistent testing procedures are used—and consistent results obtained—by those buying, selling and regulating food products in international trade.

The Supplement provides additional tests for analyzing the oil content of seeds and fruits (utilizing low-resolution nuclear magnetic resonance), measuring the content of oxidized fatty acids in vegetable oils and fats, determining organochlorine pesticides in oils and fats, determining total fat in margarine, and describes various tests to evaluate the quality of glycerine.

Standard test methods for evaluating industrial glycerine were completed and published in July. This section sets forth standard analytical methods for measuring water content of glycerine, arsenic content, alkalinity or acidity, ash content and non-glycerol organic content. Most of the test procedures are adaptations of analytical methods that are widely used in industry. To measure the amount of water in glycerine, for example, the Karl Fischer method is employed. It utilizes the reaction of water with iodine and sulfur dioxide (dissolved in reagent solution) in a pyridine/methanol solvent reagent. When water is present, the iodine and sulfur dioxide react with the solvent to form $C_5H_6N^+$ and $CH_3SO_4^-$ ions. When all the water has been consumed, excess iodine causes a colour change at the titration endpoint (electrochemical monitoring of the ionized reaction products has also been used by some laboratories). An integral part of the procedure is the precautions that are necessary to prevent contamination by condensed moisture during handling of cold anhydrous reagent solutions.

Arsenic content is measured by treating the glycerine sample with zinc and hydrochloric acid, liberating the arsenic content as arsine gas (AsH_3). In a specially-designed adsorption tube fitted to the reaction flask, arsine is absorbed by a solution of silver diethyldithiocarbamate. Colloidal silver is displaced from the complex, imparting a purplish-red colouration. The amount of arsine released is determined photometrically from the intensity of the colour produced. The method must be performed on two test samples; one "spiked" with a known amount of added arsenic. Testing both samples allows the extent of arsenic recovery to be determined. This is important, since the formation of arsine is inhibited by organic impurities sometimes present in glycerine. If less than 80% of the added arsenic is recovered, the test must be repeated with a

preliminary oxidation step to destroy the organic matter.

Test methods in the First Supplement to "Standard methods for the analysis of oils, fats and derivatives" have been published in the IUPAC journal *Pure & Applied Chemistry* (Vol. 51 (1979) No. 12 and Vol. 52 (1980) No. 8). The test methods have also been combined into a bound reprint, of which a limited number of copies are available for sale from the IUPAC Secretariat.

Professor Stig Sunner died suddenly in his laboratory on 3 June 1980, having for several years battled bravely against ill health. Chemical thermodynamicists, whether they knew him personally or not, lost a great leader and source of inspiration. Those who knew him lost a fine friend.

One of these was Max McGlashan (Professor at University College London), who reviewed a few highlights of Prof. Sunner's career in an article in *Journal of Chemical Thermodynamics.* It begins with Stig Sunner's introduction to thermochemistry by Professor Lennart Smith at the University of Lund (Sweden), where Stig was to spend the rest of his professional life. His 1949 doctoral thesis described one of the very first rotating-bomb calorimeters.

Continuing his work in thermodynamics, Prof. Sunner made original contributions in other branches of calorimetry: vaporization, reaction - solution, heat capacity and measurement of vapour pressure. He was above all a fine experimentalist, and had a flair for innovation in glass and metal and measurement technique. He authored more than a hundred publications—including many that are familiar to all chemical thermodynamicists. Perhaps equally important was Prof. Sunner's influence in papers that do not bear his name. A typical example is the highly original paper on a micro combustion bomb-calorimeter by Margaret Mansson, in which she remarked "This project was initiated by Professor Stig Sunner, in spite of considerable skepticism on my part."

One of Prof. Sunner's greatest contributions to chemistry was the very active part he played in the creation of the fine Chemical Center at the University of Lund, in which he served as the first chairman from 1967 - 1969. He was also a Member and Gold Medallist of the Swedish Academy of Engineering Sciences, and had been awarded the Norblad Ekstrand Medal by the Svenska Kemistsamfundet, the Swedish Chemistry Association.

For sixteen years, Prof. Sunner served on the IUPAC Commission on Thermodynamics, including two terms as Chairman (1969 - 73). He was also a Member (1969 - 71), Secretary (1971 - 3), Vice-President (1973 - 77) and President (1977 - 79) of the IUPAC Division of Physical Chemistry. Other IUPAC activities in which Prof. Sunner contributed was the Task Group on Key Values for Thermodynamics, on which he served as Chairman. He was co-editor of the major reference work *Combustion Calorimetry,* the first volume of the series *Experimental Chemical Thermodynamics.* Prof. Sunner was to have been the third Rossini Lecturer at the 6th International IUPAC Conference on Thermodynamics, held in August in the German Democratic Republic.

One of Prof. Sunner's favourite pastimes was talking on the telephone with friends throughout the world. For some, it is hard to believe that when the telephone rings it will not be Stig, as it had been at least once a week for many years.

Because the efficiency of energy conversion processes generally increases at higher temperature, new applications are developing for high-temperature refractory materials. At the same time, promising new techniques (laser spectroscopy, high-voltage electron microscopy, synchrotron radiation and laser heating) could provide a better understanding of high-temperature phenomena. Present theories often cannot account for physical and chemical behavior

Two views of Prof. Stig Sunner. Below, Stig Sunner was seen as a prominent and active thermodynamist. On the right (speaking with retired IUPAC treasurer Otto Horn) is Stig Sunner as most people saw him, as a personable, generous and well-liked individual.

which differs—sometimes dramatically—from that expected by extrapolating behaviour at lower temperatures. Nor can they confirm or contradict some of the conflicting values that have been reported for melting points of refractory materials (reported melting points of CaO differ by as much as 300°C).

Chemists who rely on melting point measurements and other high-temperature data are often not equipped to assess which values are most reliable—or know which values have been reported. High-temperature measurements are scattered throughout the chemical literature. The proliferation of chemical journals has made it increasingly difficult for chemists to find published values.

Few laboratories are presently involved with experimental measurements of melting points, or the compilation and evaluation of high-temperature data. In fact, support for critical compilation of high-temperature thermodynamics data has been declining. This decline, according to a report of the US National Research Council*[2], is "a 'tragedy of the commons' in which action of value to the general (chemical) community cannot compete with activities of special interest to individual scientists". The report notes that "data evaluation and compilation is considered routine and not at the frontiers of science. However, the lack of compiled data is a tremendous handicap to the development of the frontiers."

Among the groups active in the compilation and evaluation of high-temperature data is the IUPAC Commission on High Temperatures and Refractory Materials. The Commission surveys the chemical literature and publishes (four times per year) a comprehensive *Bibliography on the High Temperature Chemistry and Physics of Materials**[3]. Each issue of the bibliography typically contains several hundred literature references dealing with devices for achieving, measuring and controlling high temperatures; thermodynamic properties above and below 1000°C; phase equilibria above 700°C; and reactions above 700°C. Also listed are books and forthcoming conferences related to high-temperature chemistry.

In addition, the Commission has undertaken an evaluation of published melting temperatures of refractory materials. The first part of their report *Melting Temperatures of Refractory Oxides,* now complete, contains a compilation and evalauation of melting temperatures of SiO_2, TiO_2, ZrO_2, Al_2O_3, Y_2O_3, MgO, CaO, Sc_2O_3 and CoO, and recommends preferred values. In the case of alumina, the Commission sponsored a cooperative determination of its melting point, in which nine scientific groups from seven countries contributed experimental data.

The project is to be continued. A preliminary evaluation of lanthanide sesquioxides has been presented to the Commission by Dr. J. P. Coutures at its June 1980 meeting, and Fr. J. Hlavac is heading a task force to determine melting points of the refractory oxide HfO_2 and a more accurate value for CaO.

The 170 page hardcover 6th edition of "Standard methods for the analysis of oils, fats & derivatives" is available from Pergamon Press Ltd., Headington Hill Hall, Oxford OX3 0BW, U.K. The price is £9.50 (US$21).

[2] *High Temperature Science: Future Needs and Anticipated Developments. Available from Office of Chemistry & Chemical Technology, National Research Council, 2101 Constitution Avenue NW, Washington D.C. 20418, USA.*

[3] *A subscription to the bibliography may be obtained from Dr. M. G. Hocking, Metallurgy Department, Imperial College, London SW7 2BP, UK. The Cost (to cover printing and postage) is £5 ($11.50) per annum; airmail postage is extra.*

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Chemistry International

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to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

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Surplus fish is converted to new high-protein foods

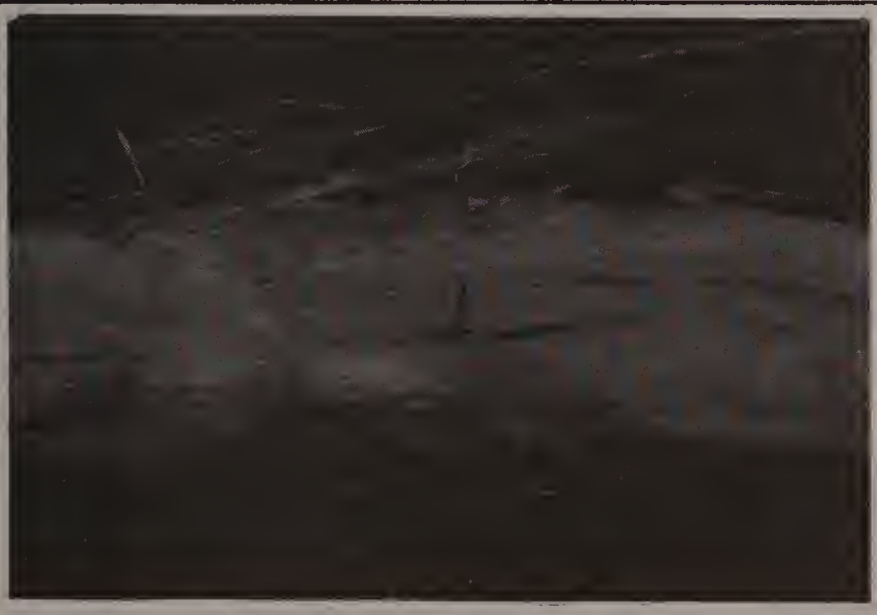
Despite malnutrition that is prevalent in many parts of the world, little attention has been directed towards full utilization of fish. Of the 70 million ton/year world fish production, nearly 10 million tons of immature "by-catch" fish (fish species that are not considered part of the traditional consumer diet) are discarded by fishing boats. During fish processing, large amounts of edible material are simply thrown away because processing equipment is not adapted to handle the material, or because no consumer market exists.

Furthermore, the global fish harvest could be extended enormously if fish species, which are not traditional foods, could be made acceptable to the consumer palate. Of particular importance is krill, a large shrimp found in subarctic waters. It is estimated that at least 100 million tons/year could be fished without depleting stocks. The potential yield of this species alone could surpass all other fish production or equal global meat production (120 millions tons/year). But unlike most fish species that are concentrated in a few fertile areas, krill are mostly found in clouds dispersed throughout the ocean. This makes krill difficult to catch. For wide-scale fishing, it will be essential to detect krill concentrations with global techniques like satellite surveillance.

All fish and shellfish are highly perishable, and spoilage is a major problem impeding full use of fish as a protein source. Canning and refrigeration can preserve fish for extended periods, but these methods are expensive and energy-intensive.

There are alternative methods which can convert small, by-catch or surplus fish to nutritious products. These products can be stored for long periods—even in hot, humid climates. Some methods have been perfected over millenia; others require high technology.

Fish products made with traditional techniques have become part of local cultures and eating preferences. No doubt, these food conversion and preservation methods could be adapted into other countries—but first, consumer tastes must be cultivated to accept the new products. This usually takes years, sometimes decades. Consumer eating habits, and not the available technology, has been the main factor inhibiting the introduction of new food processing methods. Eventually however new fish processing technologies are likely to gain acceptance in parts of the world where they have never been used before. This transfer will be a two-way exchange (involving both



Mechanically-deboned or minced fish exhibits poor texture and undergoes rapid spoilage. To upgrade these food products, the fish protein can be dissolved and then spun into an acid bath to coagulate the protein into continuous fibers. Spun Fish Fibers, shown here slightly enlarged and at 200X magnification, have excellent nutritive value and can be impregnated with different flavourings *(photos courtesy the editors of Nestlé Research News)*.

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traditional and high-technology techniques) between developed and developing countries.

Fermentation is a traditional and common method of preserving fish in Southeast Asia. Some of the food products made in this way are described in the report *Microbial Processes: Promising Technologies for Developing Countries,* published by the US National Academy of Sciences. The report points to potential "opportunities for increasing conservation of food resources through more widespread use of such methods", and speculates that "there may be an important role here for the microbiologist in improving the techniques in ways appropriate to the local situation".

Among the methods discussed in the report is the preparation of fish sauces and pastes. The procedures may differ slightly, but are basically the same. Freshly-caught fish is mixed with sea salt and placed in fermentation tanks. The salt creates an environment of high osmotic pressure in which spoilage bacteria cannot grow. Meanwhile, microorganisms in the gut of the fish and enzymes in fish tissue hydrolyze fish protein into soluble form. The result, after a year of fermentation, is a sauce containing essential amino acids, vitamins (mainly B-complex) and a high salt content. As well as this liquid product, a high-protein fish paste is produced. Fermentation for a shorter period (60-90 days) causes less protein hydrolysis and produces only fish paste. The process can be accelerated by the addition of enzymes, yielding fish paste in only 3 days.

Large quantities of fish are fermented in this way in countries of Southeast Asia. The sauces (nuoc-mam in Vietnam, patis in Indonesia and the Philippines, and nampla in Thailand) are used as condiments to enhance the flavour of rice dishes. Fish pastes are usually eaten with cereals.

The amount of fish sauce that can be consumed is limited by its high salt content (20%). These products can only make a minor contribution to the diet, despite their high protein content. However, food products with a lower salt concentration can be made be fermenting the fish in acidic solution (pH 4.5). This is similar to the preservative action of pickling, in which the solution is made acid by lactic acid-producing bacteria able to grow in a moderately saline environment (containing 2 - 5% salt). Because of the lower salt content, food preserved in this way can make a greater nutritional contribution to the diet.

While fermented fish sauces and pastes play an important role in the diet of Asians, they remain virtually unknown in industrialized countries. Nor has the Western palate yet accepted fish products made by new high-technology methods. Some of these are discussed in the 1979 edition of *Nestlé Research News* (published by Nestlé Products Technical Assistance Company in Lausanne, Switzerland).

One such product is Fish Protein Concentrate (FPC), a powder obtained from fish after extraction of water and fat. As early as 1890, fish powder was produced in Norway by drying chopped haddock in a stream of air. The protein concentrate was ground to powder and used to prepare meats on board ships. Production continued for several years, but then interest lay dormant until the 1930's. Then, investigators in Germany, Norway, South Africa and Iceland reexamined the material as a protein source. With the outbreak of WWII, the projects were discontinued, except in Germany where FPC was produced until the end of the war.

In the 1950's, research on FPC began again, mainly in Canada, the USA, Chile, Morocco and Sweden. It was widely believed that the product could alleviate malnutrition caused by a "protein gap". In 1978, E. R. Pariser, M. E. Wallerstein and co-workers published a book entitled "Fish Protein Concentrate: Panacea for malnutrition?" By this time, however, it had become increasingly apparent that malnutrition usually involved a caloric deficiency, as well as a shortage of protein. During the flurry of activity surrounding the development of Fish Protein Concentrate, little attention had been paid to the social environment, food habits and cultural patterns of the population for whom the product was intended. By late 1978, Pariser and Wallerstein responded to their own question by publishing a paper "Fish Protein Concentrate: A technology which has failed".

Mechanical de-boning of fish accelerates the process of fish spoilage and alters the fish texture so that it is less acceptable to consumers. The fish meat can be ground but, even when frozen, minced fish is stable for only about a month. In order to utilize this material, Nestlé developed a method for texturing fish protein. The protein is initially dissolved, and then extruded into an acid bath. Dissolved fish protein is coagulated into continuous fibers. The resulting spun fish fibers have excellent nutritive value and can be impregnated with various flavourings.

Another new fish product is Fish Protein Isolate (FPI). In the late 1960's, Nestlé began a programme in Sweden to develop a soluble material made from fish mince, cod filleting waste and various mixtures of waste fish. By dissolving the fish protein, a product is made similar to soya isolate, but it has a superior composition of amino acids. Different varieties of FPI were developed for use as meat extender, sausage emulsifier, egg white replacement, in ham curing and as a protein supplement in soups, bouillons and drinks.

Nestlé Products Technical Assistance Company are hesitant to disclose detailed information about the proprietary processes of their parent company, but have informed *Chemistry International* that, to their knowledge, neither Fish Protein Isolate nor spun fish fibers have yet been produced commercially in Europe.

Fermentation converts chemical waste to fuel, food and feedstocks

Rather than being considered as a disposal and pollution headache, waste streams are to an increasing extent being viewed as potential resources that can be upgraded to valuable raw materials. For many chemists and biochemists, process byproducts are becoming the starting point for some exciting chemistry, and not a final waste product for disposal. That was the clear impression conveyed by speakers at the IUPAC-sponsored 6th International Fermentation Symposium, held in July in London, Ontario (Canada). They reported intensive efforts to utilize "waste" streams as raw material sources for the production of animal feed, alcohol and methane.

With shortages nearly certain to develop for petroleum, natural gas and other traditional hydrocarbon feedstocks, industrial chemists and biochemists are eager to sniff out new sources of chemicals—regardless of how unattractive they might initially appear. Instead of oxidizing organic waste products to carbon dioxide and water, microbes can metabolize waste materials to a variety of useful products.

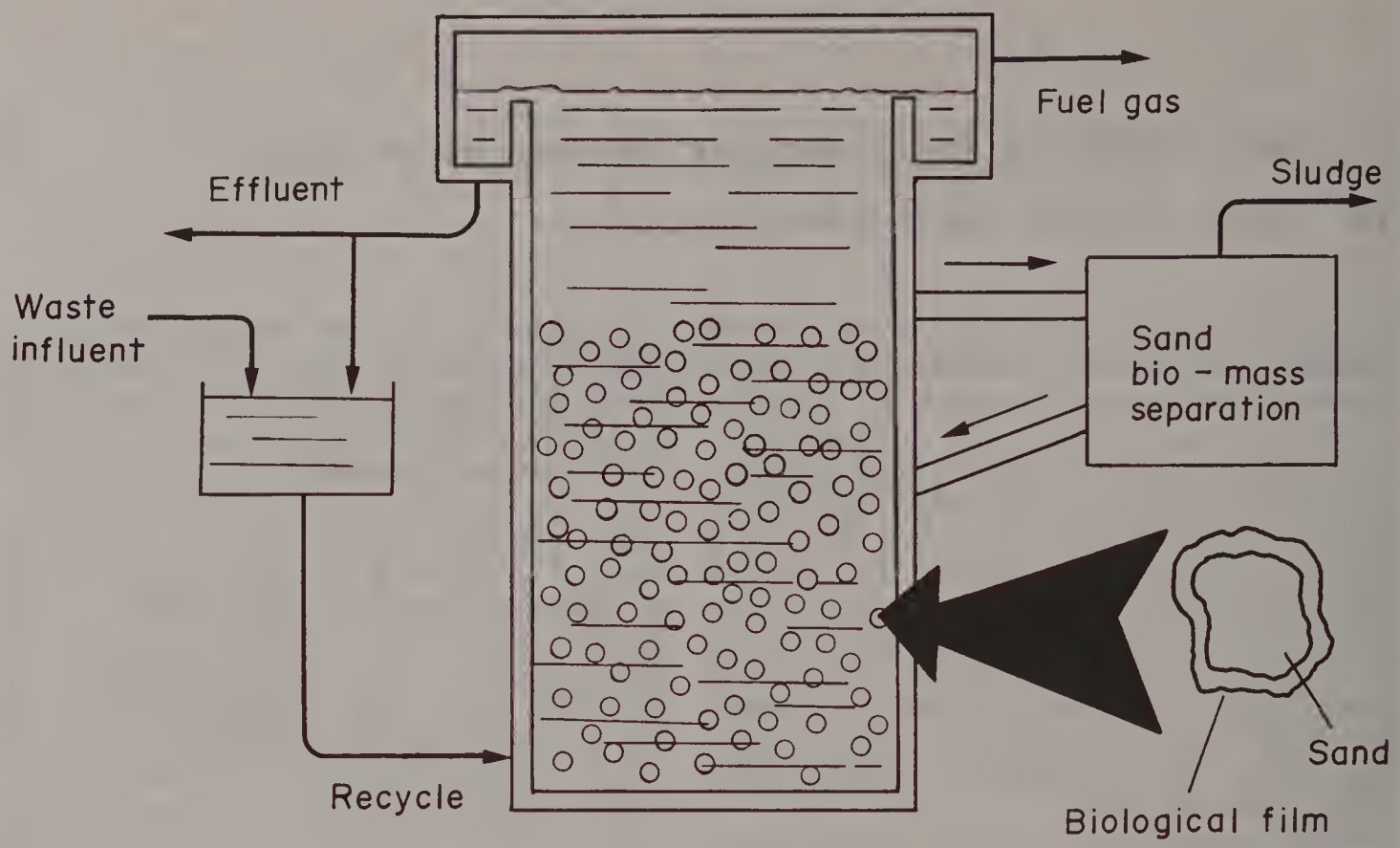
Many speakers at the Fermentation Symposium discussed their efforts to utilize food processing byproducts—corn stalks, distillery slop, rice straw, pineapple effluent and milk ultrafiltrate—while others were investigating waste streams of the chemical industry. Dr. J. G. Du Preez and other South African researchers, for example, focussed their attention on the 80 000 tons/year of dilute aqueous effluent produced by the SASOL II coal gasification plant. They demonstrated that the waste stream's organic content, mostly acetic and propionic acids, could be converted to Single Cell Protein for animal food.

From a strictly chemical viewpoint, upgrading of waste materials aims in the opposite direction from waste degradation. Yet, the technologies are closely related. The oxidation of organic waste by bacteria closely parallels the microbial synthesis of antibiotics, pharmaceuticals and food products. It might even be argued that the production of sewage sludge (an unwanted byproduct of waste treatment) is analogous to the synthesis of Single Cell Protein (a feedstuff for animals, and possibly, humans). Fermentation chemists are often called upon, at various times, to "wear two hats": that of a waste disposal specialist and of a producer of chemicals and feedstuffs.

Perhaps the simplest example of how organic waste may be converted to useful products is the production of biogas. In the absence of air (specifically, oxygen), the organic content of sewage, dung or agricultural waste can be metabolized by bacteria to produce methane (chemical aspects of biogas production are discussed in *Chemistry International,* 1979, No. 3). Although this process produces a valuable fuel gas, *an*aerobic digestion is not yet as extensively used for waste treatment as conventional *aerobic* digestion (which uses air to oxidise the waste). The reason is basically simple: because the methane product contains most of the energy content of the organic waste feed, methanogenic bacteria must metabolize the waste with a minimum expenditure of energy. This they do, steadily and efficiently, but at a characteristically sluggish pace. As a result, anaerobic digestors need to be much larger than aerobic digestors with the same waste treatment capacity. A favourable consequence of their slow growth is that methanogenic bacteria produce only a tenth as much excess bacterial mass (sewage sludge). Furthermore, since the nitrogen and mineral content of the waste are not destroyed by anaerobic digestion, a valuable fertilizer is produced as byproduct. The outstanding attraction of biogas generation is that it represents an integrated system of fuel production, mineral recycling and waste disposal.

Despite the relative bulkiness of anaerobic digestors, biogas production is becoming commonplace in many areas of the world. It is estimated that 200 000 family-size biogas plants are operating in the Szechuan province of China. In India, where 12 000 units provide cooking gas, experiments are being carried out to use biogas to power petrol and diesel engines. About 30 000 biogas plants are operating in the Republic of Korea, and Malaysia is investigating the utilization of biogas produced by sewage works for the generation of electricity.

The use of anaerobic digestors to produce methane from waste could be greatly accelerated by new technology presently being developed or already available. Several new digestor designs are especially promising. One, a digestor vessel in which the methanogenic bacteria grow on the inside surface of tubes, was developed by Dr. I. van den Berg and coworkers at the National Research Council in Canada (the main features of their digestor were previously reported in *Chemistry International,* 1980, No. 2). At the 6th International Fermentation Symposium, Dr. van den Berg confirmed earlier expectations that the very large surface area for bacterial growth allows the digestor to produce methane at a much faster rate than digestors of conventional design. He also reported that tubes made of



Organic waste can be converted to fuel gas and fertilizer solution by anaerobic digestion. The anaerobic digestion of waste, which is usually a slow process, occurs at a greatly accelerated rate in the *Anitron* Process. Here, anaerobic bacteria grow on the surface of sand particles. The sand grains are suspended and fluidized by the upflow of waste solution, providing an enormous surface area of bacterial film in contact with the rapid flow of waste solution.

baked clay were far superior as a support for bacterial growth than glass or plastic tubes used in earlier experiments.

Methane is also produced at a much enhanced rate in a fluidized bed reactor developed by Dorr-Oliver Inc and now being tested for commercial use. Their *Anitron* system utilizes a bed of fine sand particles, on which grows a film of methanogenic bacteria. The tremendous surface area of the bacterial film allows a large volume of organic waste to be digested in a remarkably compact reactor. The flow of waste upward through the sand bed (typically at a velocity of 10 mm/second) "fluidizes" the bed, that is, suspends the bacteria-coated sand in the flow and maintains intimate contact between the bacterial film and the waste stream.

As the bacteria metabolize the waste and grow, the film thickness increases. Because the bacterial coating has lower density than sand, the particles become less dense and are carried to greater height by the flow of waste solution. At a specified height, the bacteria-coated particles are tapped from the fluidized bed. Some of the bacterial covering is mechanically removed, and the partially stripped particles are returned to the bed. The separated bacterial mass is collected as sewage sludge. Recycling of sand particles in this way allows the thickness of the bacteria film to be precisely controlled, a capability that is unique among anaerobic digestion reactors.

The Dorr-Oliver fluidized bed reactor was *not* developed specifically for anaerobic digestion of waste. In fact, most present studies are evaluating the process for bacterial *oxidation* of waste. In these applications, oxygen is generated on-site and injected directly into the waste stream entering the reactor. In his conference lecture describing the capabilities of the fluidized-bed digestor, Senior Process Engineer Paul M. Sutton discussed one such application as an illustration. However, he later emphasized to *Chemistry International* that the reactor was equally suited—and in some ways, better suited—for anaerobic digestion. Of course, when operated so as to produce biogas, the fluidized bed reactor does not use oxygen. No oxygen-generating equipment is needed, eliminating the major energy-consuming component and a possible source of technological difficulty.

It would appear that the outstanding feature of the *Anitron* process—the ability to treat a much larger volume of waste than conventional reactors of the same size—would be of greatest advantage when applied to anaerobic digestion. The process is especially suited for wastes in which the organic content consists mostly of dissolved, rather than suspended, material. Dorr-Oliver is presently evaluating their process for anaerobic digestion of dairy and soybean processing waste. A future study is planned to investigate the treatment of chemical waste associated with nylon manufacture.

Gasified Coal—starting point for chemical manufacture

The chemical feedstock of the future may be "synthesis gas"—a mixture of carbon monoxide and hydrogen made from coal. Synthesis gas can be used for large-scale production of hydrogen, ammonia, methanol, alcohols, acetic anhydride and acetic acid. New processes are being developed to use synthesis gas as the starting point for manufacture of formic acid, ethylene glycol, vinyl acetate, ethylene and propylene, ethanol, acetonitrile, and terephthalic acid.

Synthesis gas has the potential to be a universal raw material for a coal-based chemical industry. However, gasification of coal to synthesis gas is expensive, and some of the energy content of the coal is lost as waste heat. Some of these limitations stem from the lack of development of coal gasifiers. Although the classic Lurgi gasification process has undergone continued improvement since it was demonstrated commercially in 1936, there had been no major attempt at redesign. So too for the other two major coal gasifier designs—the Winkler gasifier (introduced in 1926) and the Koppers-Totzek gasifier (introduced in 1949).

Now, the development of an entirely new generation of coal gasifiers has been reported at an international Coal Chemistry conference*. These new gasifiers promise substantially higher thermal efficiency and lower operating cost. One type appears especially suited to produce synthesis gas feedstock for the chemical industry. It can accommodate nearly any kind of coal, gasifies it in seconds, and produces "pure" synthesis gas with no tars or byproducts. These second-generation gasifiers could greatly accelerate the development of a world-scale chemical-from-coal industry.

*COAL CHEM-2000, September 1980, Sheffield UK, proceedings from the Institution of Chemical Engineers, George E. Davis Bldg, 165-171 Railway Terrace, Rugby, Warks CV21 3HQ, UK

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Coal gasification has been used for well over fifty years to provide heating gas and synthesis gas for the manufacture of ammonia. The introduction of innovative gasifier designs in the 1930s gave great impetus to coal gasification, but the initial advance of coal gasification as a source of organic chemicals was soon halted by competition from cheap and plentiful petroleum feedstocks. Coal gasification technology remained essentially frozen until fresh interest in gasifier development was rekindled by the oil crisis. In this new technological climate, programmes were begun to develop an entirely new generation of coal gasifiers. They started at nearly the same point where coal gasification technology had been left 30 - 40 years before.

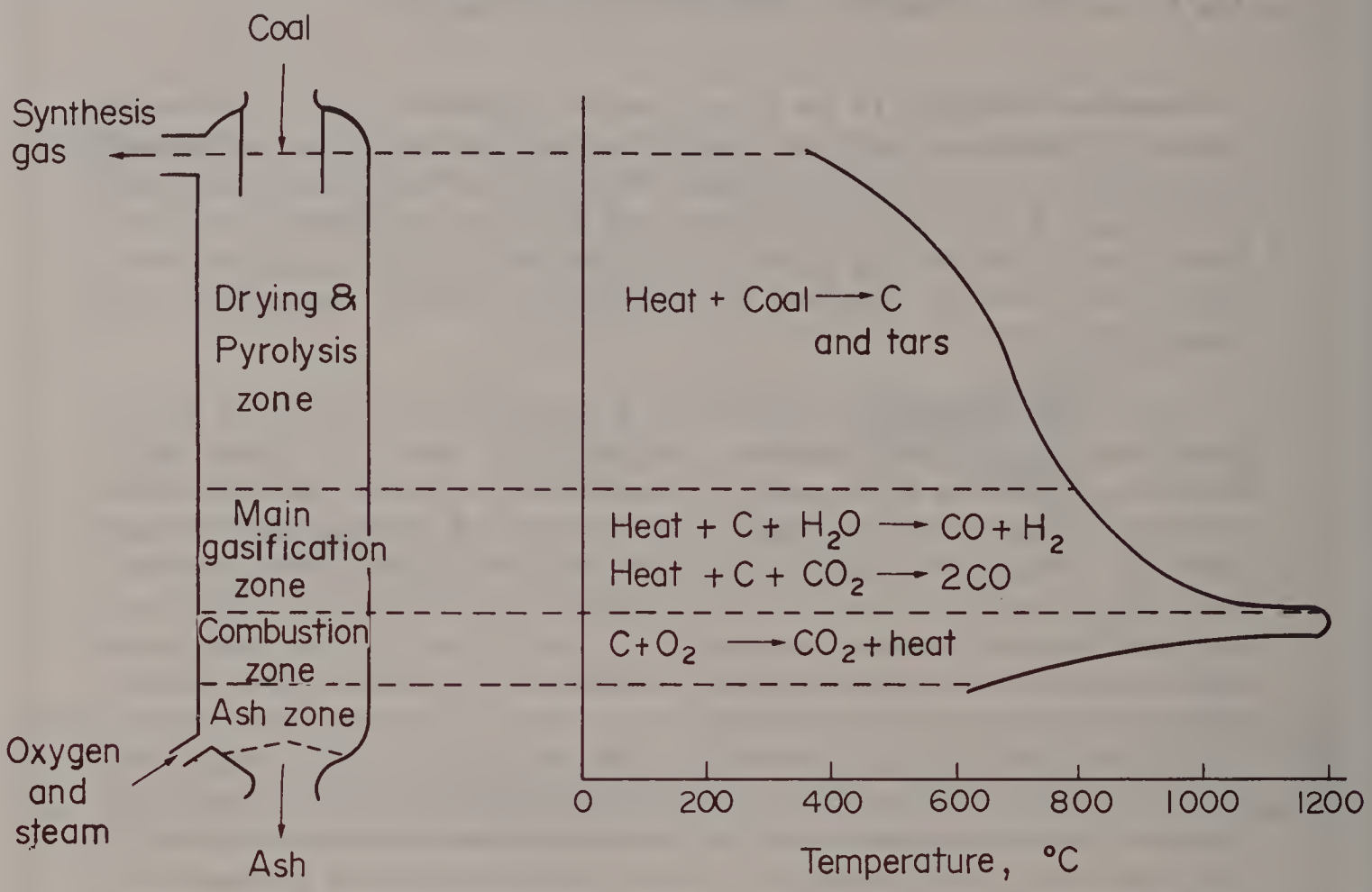
We begin our story at the same point, with the Lurgi gasifier—one of the most successful 1st generation coal gasifiers. About 120 have been built since the first demonstration unit began operation in 1936. Its simple fixed-bed counter-current design provides a good illustration of the chemistry involved in coal gasification.

The Lurgi gasifier basically consists of a cylindrical reactor vessel, into which coal is fed at the top. On its downward passage through the reactor, the coal is first dried and carbonized. The resulting char undergoes gasification, and finally combustion, before residual ash passes through a grate at the bottom of the reactor.

Air or oxygen and steam is injected at high pressure into the *combustion zone* at the bottom of the reactor. There, oxidation of coal char forms carbon dioxide, and liberates an enormous amount of heat. This heat is carried upwards by the flow of hot gases.

Immediately above the combustion zone, the 1200°C gases contact coal char in the *gasification zone*. There, the high-temperature of the gases drives endothermic reactions. Coal char (basically, carbon) reduces carbon dioxide to carbon monoxide. The

Fixed-bed gasifiers, like the Lurgi reactor, rely on the exchange of heat between the upward flow of gases and the downward passage of coal. Heat energy for the gasification reactions is provided by combustion of coal char. Temperatures in the combustion zone rise to about 1200°C, and would rise even higher if large amounts of steam were not injected. The high temperatures drive the main heat-absorbing gasification reactions, which produce hydrogen and carbon monoxide.



As well as H_2 and CO, the fixed-bed gasifier also produces significant amounts of methane. Some methane is evolved during the low temperature break-down of coal in the pyrolysis zone. The rest is formed in the gasification zone by reaction of coal char with hydrogen. This last reaction liberates heat. While methane production is favoured in the Lurgi reactor, the reaction equilibrium is shifted away from methane production at the higher temperatures of slagging gasifiers (*Diagram adapted from paper presented by Dr. K. R. Tart to the COAL CHEM - 2000 conference*).

coal char also reacts with steam to produce hydrogen and carbon monoxide. These reactions cool the upflowing gases, and hence, the temperature of the coal bed decreases through the gasification zone. Two other reactions in the gasification zone produce heat, but not nearly enough to offset the heat absorbed by endothermic reactions. Yet, these play an important role in determining the composition of the product gas, as we will see shortly.

The rising gases have lost much of their combustion heat by the time they have passed through the gasification zone into the *drying and pyrolysis zone.* The gases are still hot enough to first dry, and then carbonize, the coal feed. Methane, tars and oils are evolved and the remaining char consists almost entirely of carbon . . . and ash.

By the time the gas has left the reactor, it has expended most of the initial combustion heat in driving endothermic reactions. This is a consequence of the counter-current flow (that is, flow in opposite directions) of hot gases and coal. The gas cools as it rises upward through the bed of coal and char, just as the coal is heated to increasingly higher temperature during its downward passage. This is convenient, as the gas would need to be cooled anyway for removal of tar, oils and H_2S.

Another desirable feature is that the gasifier operates at high pressure (20-25 atmospheres). This is especially important if the synthesis gases are to be used for chemical manufacture. Chemical processes using synthesis gas generally operate at high pressure. Compression of synthesis gas produced by the gasifier would require a very large amount of energy. It is much better to compress the oxygen or air, and inject it into a gasifier maintained at high pressure. For each mole of oxygen injected, about four moles of pressurized synthesis gas are produced by gasifier reactions.

Ash does not contribute to the reactions we have discussed, yet indirectly, it dominates the reaction chemistry of the Lurgi reactor. If the gasifier's combustion zone is allowed to become too hot, the ash fuses into clinkers and does not drop through the rotating grate at the bottom of the reactor. In order to keep combustion zone temperatures below the ash clinkering temperature, a large amount of steam is injected into the reactor. Typically, about 7 volumes of steam are injected into the base of the reactor for each volume of oxygen. The consumption of steam is 3-4 times the weight of the coal feed, and represents a substantial energy input to the gasifier. High steam consumption has been a major factor undermining the efficiency of Lurgi coal gasifiers.

Beginning in 1974, the British Gas Council under-

took development of a new type of fixed-bed Lurgi-type gasifier. By reducing the amount of steam, the temperature in the reactor combustion zone is allowed to rise as high as 2000°C—high enough to melt the ash into a molten slag. The slag pours out of a tap hole at the bottom of the reactor and is quenched by a reservoir of circulating water.

The Slagging Gasifier produces a synthesis gas with significantly less hydrogen and more carbon monoxide. At the lower temperatures in the conventional Lurgi reactor, the relative proportions of H_2 and CO are altered by the "shift reaction". Carbon monoxide reacts with steam to form hydrogen and carbon dioxide. The reaction, which evolves heat, occurs to a much lesser extent in the Slagging Gasifier. Higher temperatures and the lower concentration of steam depress the reaction equilibrium so that less carbon monoxide reacts, and less hydrogen is formed.

Operation at higher combustion temperatures also causes about 15% less methane to be produced in the British Gas Slagging Gasifier. Methane is still evolved by the breakdown of coal in the pyrolysis zone, as in the Lurgi Gasifier. However, methane is no longer formed in the gasification zone by reaction of char with hydrogen. Because this reaction evolves heat, the reaction equilibrium is shifted away from methane production. The high temperatures almost completely suppress the formation of methane in the gasification zone.

The clear advantages of the British Gas/Lurgi Slagging Gasifier were pointed out to the COAL CHEM 2000 conference by Dr. K. R. Tart of the British Gas Corporation. He described the operation of a modified Lurgi gasifier during extensive tests at the Gas Council's Midlands Research Station. A wide range of coal was gasified during six years of testing. During a total 4000 hours of operation, the Slagging Gasifier has demonstrated that it can produce 2 - 3 times more synthesis gas than a conventional Lurgi gasifier of the same cross-sectional area. It used 4 - 5 times less steam than a conventional Lurgi gasifier. Perhaps most important, it attained a higher thermal efficiency (energy content of fuel gas produced/energy content of coal and steam consumed). With Pittsburgh 8 coal, for example, the Slagging Gasifier achieved a thermal efficiency of 80%. The same coal is gasified with 62% efficiency in a conventional Lurgi gasifier.

The British Gas/Lurgi Slagging Gasifier clearly represents an enormous step forward in coal gasification. But it still is subject to two important limitations.

Like the conventional Lurgi gasifier, the Slagging Gasifier uses lump coal. All fixed-bed gasifiers have limited ability to gasify small particles. These are always present in coal. Coal produced by strip mining usually contains at least 20% coal particles of less that 5 mm diameter. Mechanical deep mining yields up to 40% fine particles. The slagging gasifier has a maximum tolerance of about 30% coal "fines".

A second feature with which we must be concerned is the 6 - 7% content of methane in the product gas This may, or may not, be a limitation—depending on whether the gas is to be used for chemical manufacture or fuel. Although methane comprises a relatively small fraction of the product gas, it contains much of its energy content. The molar combustion energy of methane is three times as much as hydrogen or carbon monoxide. If the gas is to be upgraded to substitute natural gas (SNG), the high methane content is highly desirable. Indeed, this is what the British Gas Corporation had in mind when they developed the Slagging Gasifier. However, if the synthesis gas is to be used to make chemicals, we must then steam reform the methane to produce more synthesis gas. Simply disposing of the methane would represent an unacceptable loss of energy.

Alternatively, methane can be recovered as a byproduct for use as fuel gas. This could be a practical alternative if the coal gasification plant is integrated into a chemical/energy industrial complex. It appears quite feasible that central gasification plants will supply both fuel gas (for furnaces, kilns etc.), and synthesis gas for local industry.

The third alternative is not to generate methane in the first place. The ideal gasifier for chemical synthesis would produce no methane, no tars, no oils—just "pure synthesis gas". Ideally, the reactor should be able to gasify virtually any coal even if it has a high content of fine particles. And it should achieve the same high gasification rate as the Slagging gasifier. All these characteristics are achieved in the Entrained Flow Gasifier, and that is why this type of gasifier is likely to become *the* gasifier upon which is based the chemical industry of the 21st century.

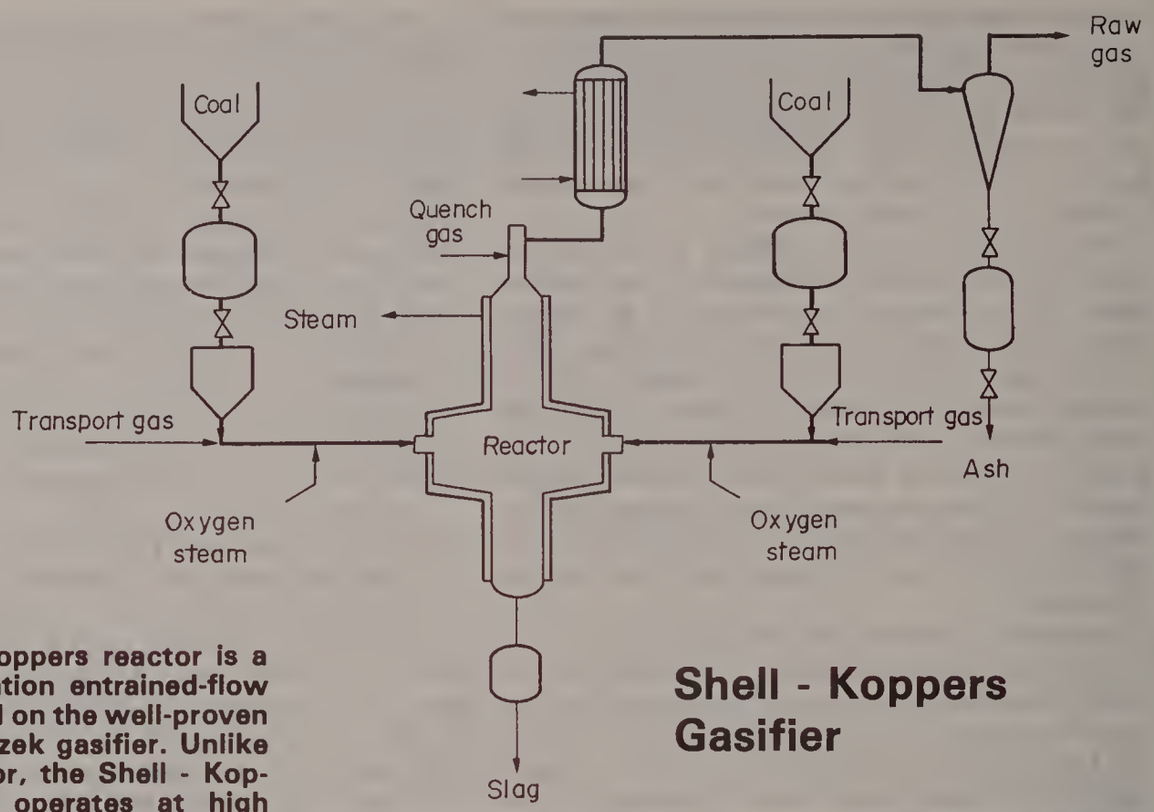
Entrained Flow Gasifiers are not new. Since 1949, the Koppers-Totzek gasifier has been competing against the Lurgi fixed-bed reactor. It has been the most successful reactor for production of synthesis gas. About 53 gasifiers have been installed at 21 plants. Of these, all but two have produced synthesis gas for the production of ammonia or methanol.

The Koppers-Totzek reactor consists of an empty cylindrical vessel into which oxygen, steam and *pulverized* coal are fed through two or four burner nozzles. The gasifier has the distinct advantage that it can accept all types of coal. A high content of fine coal particles presents no difficulty, as in fact, all the coal feed must be dried and pulverized to less than 0.1 mm diameter.

Because of their small size, coal particles blown into the reactor undergo combustion, gasification and pyrolysis within a few seconds (as compared with up to an hour in the Lurgi gasifier). All three processes occur simultaneously, and virtually none of the initial pyrolysis products—methane, tar and oil—survive the 2000°C temperature. These hydrocarbons react to yield an equilibrium mixture of carbon monoxide and hydrogen.

Virtually no methane is formed by the reaction of char with hydrogen, as this reaction is suppressed by high temperatures. Thus, the product gas contains insignificant amounts of methane, no tar, and no other organic impurities. It is nearly pure carbon monoxide and hydrogen (although it still needs to be scrubbed of CO_2, H_2S and other sulphur-containing impurities).

Entrained flow gasifiers use a concurrent flow of gas and coal: that is, the coal particles flow in the same direction as the hot gases. In fact, the coal particles are blown through the reactor by oxygen and combustion gases (hence, the particles are "entrained" in the gas flow). The heat content of the gas

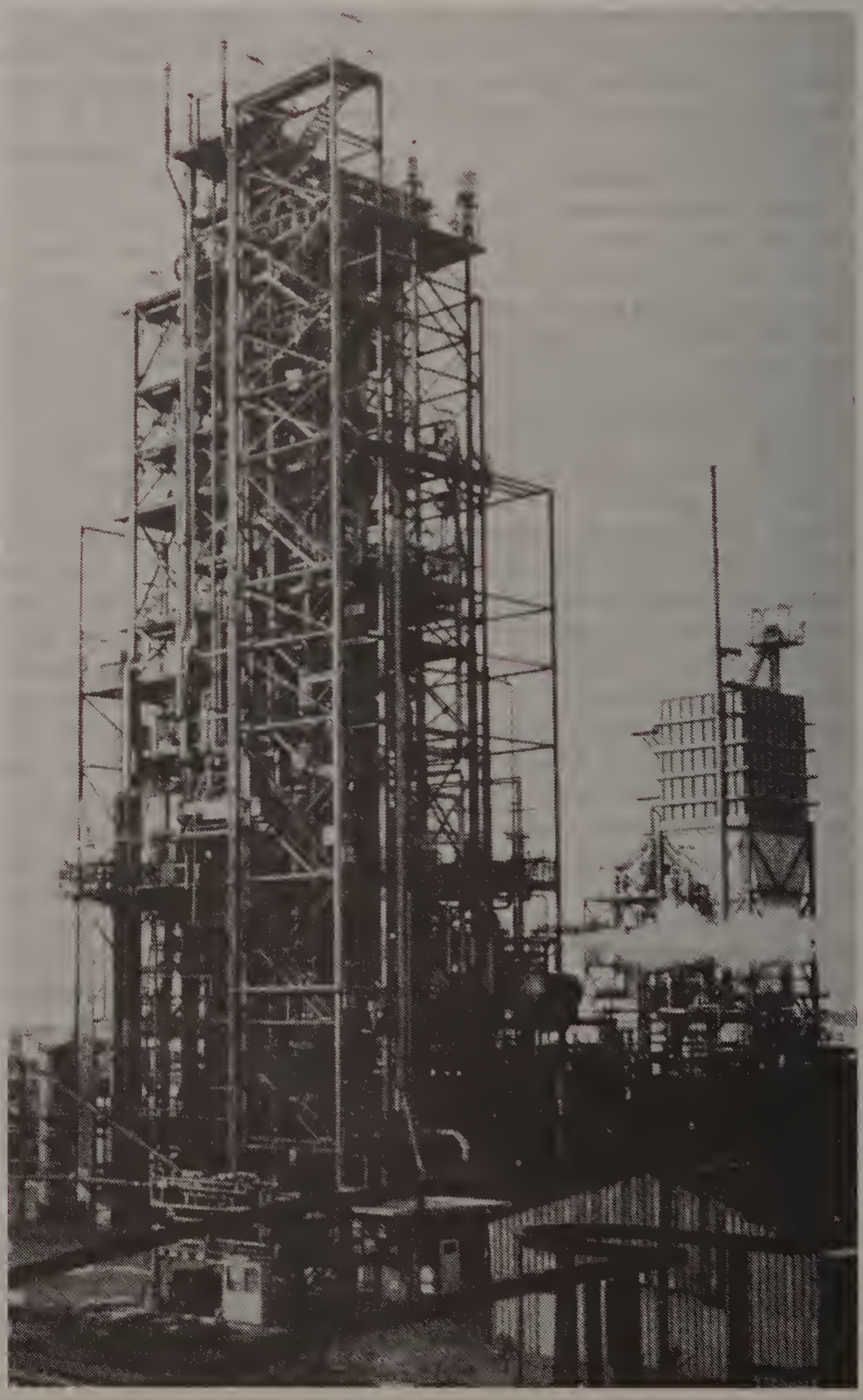


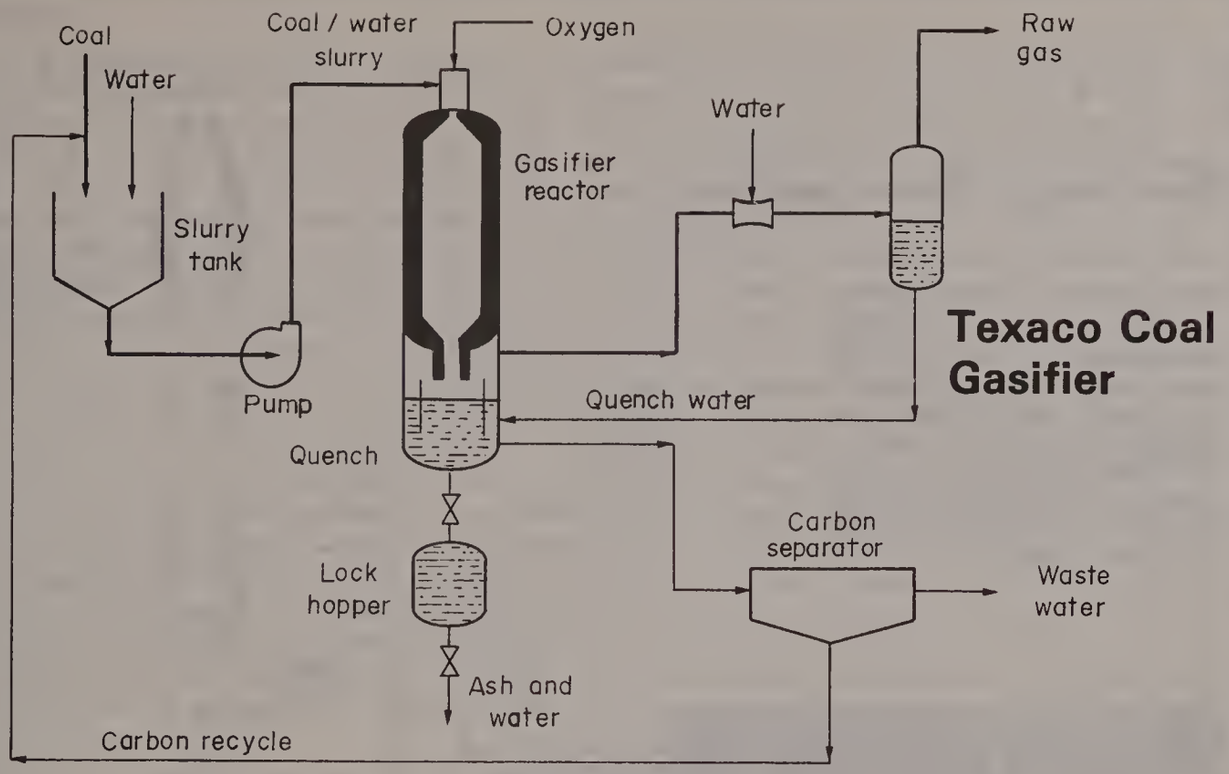
Shell - Koppers Gasifier

The Shell - Koppers reactor is a second-generation entrained-flow gasifier, based on the well-proven Koppers - Totzek gasifier. Unlike its predecessor, the Shell - Koppers gasifier operates at high pressure (30 atmospheres), which allows more efficient and economic operation. The Shell - Koppers gasifier also has higher capacity: commercial reactors are expected to gasify 1500 tons of coal per day—twice the capacity of its predecessor. A 150 ton/day pilot plant (shown here) is presently in operation in Harburg (Federal Republic of Germany).

In the process, coal is pulverised to less than 0.1 mm, pressurized and pneumatically fed into diametrically-opposed burners at the bottom of the reactor vessel. Oxygen and steam are simultaneously fed to the burners, and a flame-like reaction occurs with localised temperatures as high as 2000°C. The reactor exit temperature however will not normally exceed 1500°C. The reactor is a water-cooled chamber with a thin refractory lining, and may incorporate two or four burners. The molten slag runs down into a water-filled chamber in the base and is removed. However, some slag droplets pass upwards with the raw exit gases and these must be solidified before entering the waste heat boiler situated at the top of the gasifier. This is achieved by quenching the exit gases below 900°C with recycled product gas.

The Shell - Koppers process will accept a wide range of coals. However, the moisture content of the coal feed must be fairly low, and pre-drying will normally be required.



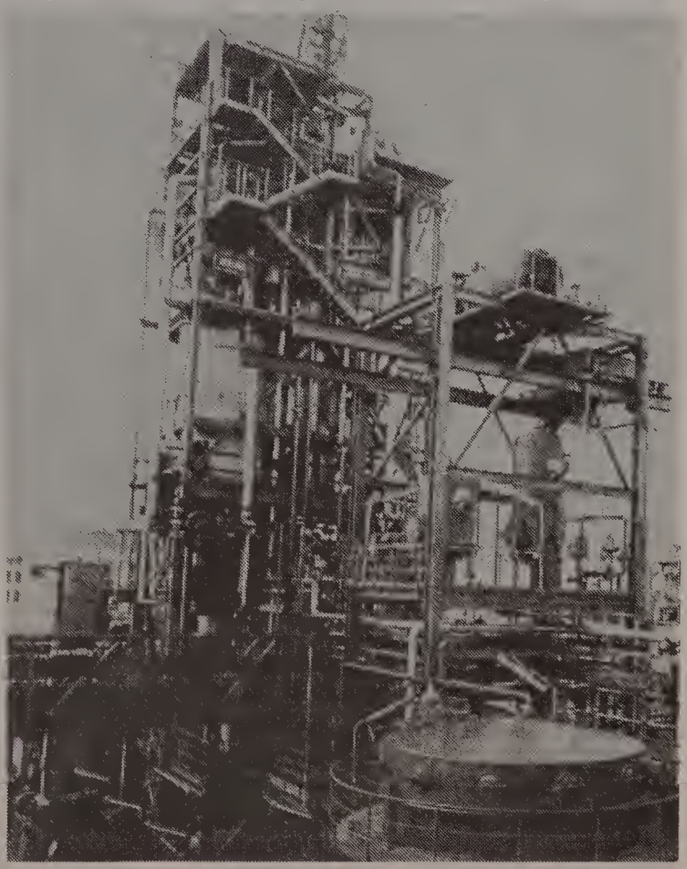


Texaco Coal Gasifier

The Texaco Coal Gasification Process does not require low moisture content in the coal feed: in fact, coal particles are mixed with water and injected into the reactor as a wet slurry. The process is best suited for low-ash coals. As with the Shell - Koppers reactor, fluxing agents may be needed to maintain the molten ash in a fluid state, especially for coals with high ash fusion temperatures.

In the Texaco process, coal is pulverised to less than 0.1 mm diameter and then slurried with water. The slurry is injected with oxygen into the top of a refractory-lined entrained-flow gasifier through a special burner. Hot product gases at about 1400°C carry the slag downwards into a quench section below the gasifier. Some unburned soot will be carried with the hot exit gases. This is removed by a water scrubbing system, made into a concentrated slurry, and recycled back into the reactor.

A demonstration 150 ton/day Texaco coal gasifier has operated successfully, at up to 40 atmospheres pressure, at the Ruhrchemie factory in Oberhausen-Holten, West Germany. Ruhrchemie has recently begun to use the synthesis gas for the manufacture of alcohols. A second gasifier is under construction at TVA's Muscle Shoals ammonia plant. The Texaco coal gasifier could therefore claim to be the first second generation gasifier to become truly commercial.



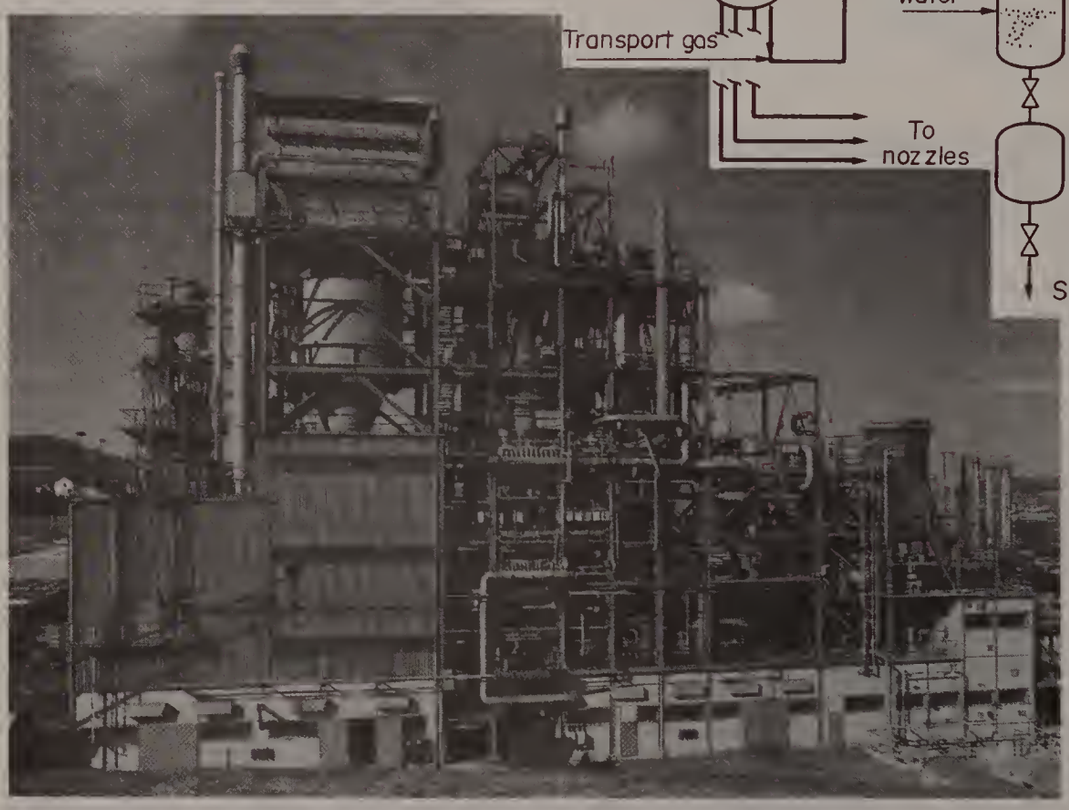
is not dissipated in pre-heating and pyrolyzing the coal, as in fixed-bed reactors. The synthesis gas retains the high temperatures of combustion, and exits the reactor with very high heat content. The heat may be used to generate high-temperature steam to drive a steam turbine, and this mechanical power utilized to power gas compressors.

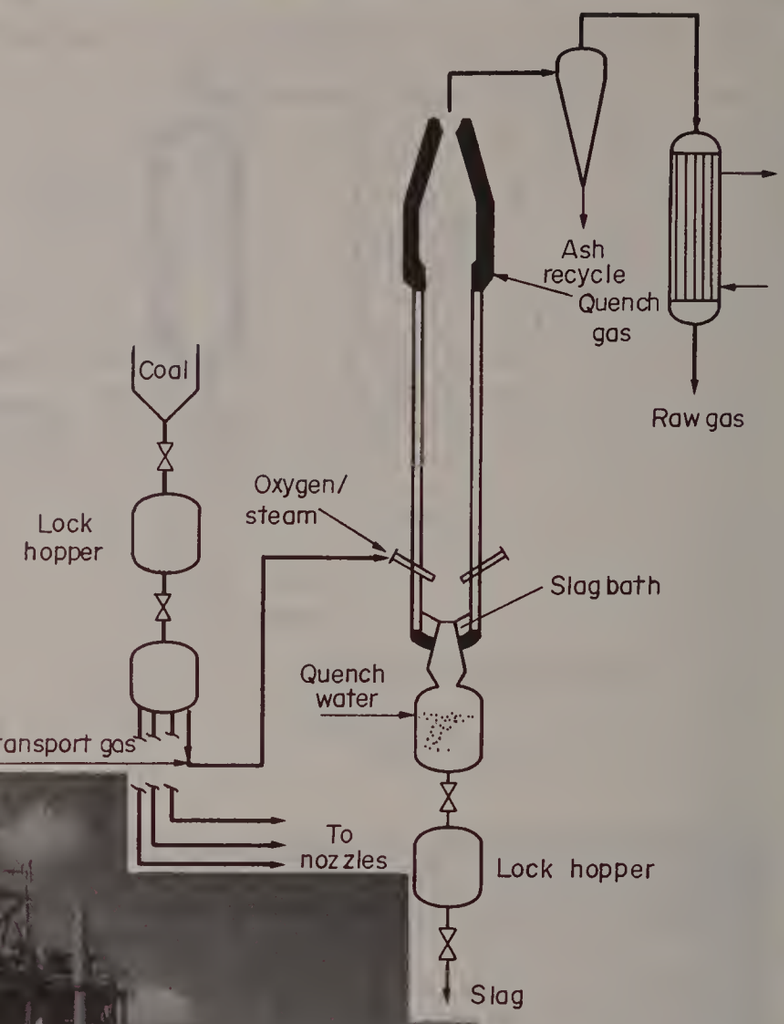
One obvious disadvantage of the Koppers-Totzek Gasifier is that it operates at about atmospheric pressure. The synthesis gas must be compressed to high pressure before it can be used to make ammonia, methanol or other chemical products. This is far less energy-efficient than injecting oxygen and steam into a pressurized reactor.

To overcome this limitation, the Koppers-Totzek reactor has been modified to operate at high pressure (30 atmospheres) through a joint development effort. The Shell Oil Company had successfully marketed a high-pressure oil gasification process for many years, and they joined Koppers to adapt their process for coal. The result was the successful development of a high-pressure entrained flow coal gasifier, the Shell-

Saarberg - Otto Gasifier

The Saarburg - Otto Gasifier appears to have a distinct advantage for coals with high ash fusion points. It has many other features which make it attractive for producing synthesis gas for chemical manufacture, but it is still in the early stages of development.





The Saarberg - Otto Company are operating a 250 ton/day coal gasifier pilot plant at Saarbrücken, West Germany. In this unit the feed coal is not pulverised, but is only ground to less than 3 mm. The coal is dried, pressurised in a lockhopper system, and pneumatically injected into the gasifier through four nozzles in the reactor base. Oxygen and steam are injected simultaneously with the coal. The nozzles are angled downwards towards a bath of molten slag in the base of the reactor, and temperatures of around 2000°C are produced in this zone, in which most of the coal is gasified. The gas then passes upwards through an 'after-gasification' zone and finally through a quench section at the top of the gasifier where the gas is cooled to about 850°C by addition to cold recycle gas. This quench section is necessary in order to solidify the liquid slag droplets being carried upwards with the gas.

In addition to the slag bath, the Saarberg - Otto gasifier has another novel feature. The reactor walls consist of cooling tubes in the gasification and after-gasification zones, instead of refractory lining. These tubes are protected by a layer of slag solidified on the tube walls. The absence of a refractory lining to the reactor means that much higher gasifier temperatures, (1600 - 1700°C), can be used than with other entrained-flow gasifiers such as the Texaco and Shell - Koppers. This enables coals with very high ash fusion points to be gasified. Because of the high operating temperatures, no tars or oils are produced, and the methane content of the synthesis gas is very low. Furthermore, the Saarberg - Otto Gasifier has a very high capacity. A 3-metre diameter reactor will gasify 1000 tons/day.

Koppers reactor.

Two other entrained-flow gasifiers are now at or near a commercial stage of development. The Texaco entrained-flow gasifier is an adoption of Texaco's process for the partial oxidation of oil, of which more than 75 plants have been built. In the process, pulverized coal is slurried with water and introduced with oxygen through a special burner at the top of the gasifier vessel. Hot gases and molten slag pass downwards into a quench section below the gasifier. The gasifier can accept a wide range of coals but, as with other slagging gasifiers, fluxing agents may be needed to maintain a fluid slag. This is particularly true for coals with high ash fusion temperatures.

The Saarberg-Otto gasifier appears to have a distinct advantage over other slagging gasifiers for handling of coals with high ash fusion points. Coal feed is not pulverized, but only ground to about 3 mm. The process has many features which make it attractive for the production of synthesis gas, but it is less developed than the Shell-Koppers or Texaco gasifiers. It should be available for commercialization within the next five years.

Entrained-flow gasifiers such as the Koppers-Totzek, Saarberg - Otto, Texaco and Shell - Koppers, produce clean synthesis gas virtually free of hydrocarbons and tar. Hydrogen and carbon monoxide are typically present in the synthesis gas at a molar ratio of about 0.5. For chemical production, the relative H_2/CO content will need to be adjusted to the particular process. This is usually accomplished by the "shift reaction", in which carbon monoxide is reacted with steam to form hydrogen (and byproduct carbon dioxide). The shift reaction is carried to the maximum extent for the production of ammonia, which is made entirely from hydrogen and nitrogen (the N_2 is separated from air). The H_2/CO ratio of the synthesis gas is adjusted to a value of 2 for the production of ethylene, methanol, ethanol and other alcohols. Somewhat less hydrogen, a H_2/CO ratio of 1.5, is needed for ethylene glycol manufacture. Carbon monoxide may be recovered from synthesis gas (cryogenically or by absorption) for the production of acetic acid from CO and methanol. Carbon monoxide is also isolated from the synthesis gas to make acetic anhydride or phosgene.

In addition to the processes which are commercially available, new chemical production routes starting with synthesis gas are being developed. A coal-based plant (based on Halcon and Eastman Kodak technology) is planned to produce acetic anhydride from methanol, acetic acid and carbon monoxide—all of which can be derived from synthesis gas. Formic acid can be produced catalytically from CO using technology developed by Scientific Design and by Leonard Engineering (based on the Leonard Process, Kemira Oy are planning to construct a plant in Finland). Halcon are now considering commercialization of their process to make vinyl acetate from synthesis gas, methanol and acetic acid. Union Carbide, Dupont and Redox Technology are developing a process to make ethylene glycol directly from synthesis gas.

Other processes are only at an early stage of development, but show promise. Ethylene and propylene may be made directly from synthesis gas by a process using zeolite catalysts (being developed by Mobil and BASF). Initially the process will use methanol as an intermediate, but ultimately it may be possible to go directly from syngas to olefins without intermediate steps. Conversion of synthesis gas to ethanol is being investigated by Shell, IFP and Union Carbide. Monsanto are studying the direct formation of acetonitrile from syngas and ammonia. Ruhrchemie and Sasol have been studying the production of ethylene from synthesis gas using Fischer -Tropsch catalysts. And Mitsubishi Gas Chemical are studying the possibility of producing terephthalic acid from toluene and carbon monoxide.

The big question concerning the changeover of the chemical industry to coal feedstock is not *if* it will happen, but *when*. Development of new gasification reactors and new synthesis routes are proceeding in pilot and demonstration plants. However, conversion of the chemical industry on a world-scale will require an investment of hundreds of billions of dollars. Before taking that step, the chemical industry will likely pause until it appears that coal is economically competitive with petroleum as a basic raw material. The time scale will be influenced by how quickly petroleum increases in price. It also depends on the cost of coal, and that can vary as much as tenfold from country to country.

Among the first countries to introduce coal-based chemical industries will likely be the United States, Australia, South Africa and Canada. These countries have very large deposits of coal which can be mined at low cost. But the USSR, China, Federal Republic of Germany, Poland and the United Kingdom also have large coal deposits and will likely develop coal-based chemical industries as well.

So far, South Africa is the only country to exploit its coal resources on a massive scale for hydrocarbon synthesis. The South African government has been motivated by strategic and political factors—rather than economics—to develop an indigenous supply of hydrocarbon fuels and chemicals. Thus in the 1950's, the Sasol I plant was built to demonstrate the feasibility of producing liquid hydrocarbons from synthesis gas. South Africa chose to use technology which had then been well-proven: the Lurgi gasifier to provide synthesis gas, and the Fischer - Tropsch reaction to produce hydrocarbons. Based on their operating experience with Sasol I, the South Africans undertook construction of a much larger plant, Sasol II, which began operation in 1980. An identical plant, Sasol III, is now under construction. When both commercial plants are operating in 1983, they will provide South Africa with half its needs of motor and diesel fuel.

Coal gasification will not be limited to countries with large coal resources. No doubt, some countries will follow the past example of Japan in providing overseas investment and technology to secure supplies of raw materials. The high risks of *not* having a coal-based industry, and the high cost of building one, will create rich opportunities for partnerships in coal, investment capital and technology.

HAIR

Do you want to know if an individual lives near a metal smelter; has been exposed to toxic elements; is schizophrenic; suffers from diabetes, hypertension or rheumatoid arthritis? You might find the answers in his hair. Contained within its chemical structure is a record of the body's metabolism of trace elements. Advances in hair analysis are revealing how to "unlock" and interpret this information to monitor our environment and health.

A monitor of chemical exposure and disease

by Sidney A. Katz and J. D. Wood
Rutgers University (USA)

In recent years, the determination of trace element levels in human scalp hair has become popular for monitoring environmental exposures, evaluating heavy metal poisoning, assessing nutritional status, and diagnosing diseases. Hair of normal, healthy individuals generally contains each trace element within a well-defined range of concentration. Marked deviations from the values indicate physiological or environmental disorder. The same is true of element levels in blood and urine—the media used by conventional methods—with one basic difference.

Trace elements are, for the most part, transported from organ to organ by the blood. The residence time for a given trace element in the blood (in the form of either an ion or compound) is relatively short. Elemental concentrations in blood and urine fluctuate in response to changing physiological and/or environmental conditions. Thus, blood is not a reliable tissue for evaluating trace element levels in body organs resulting from transient metabolic or environmental factors. On the other hand, blood and urine analyses are very helpful in identifying chronic disease states and continuous environmental exposure to trace elements. For example, Wilson's disease (due to abnormal copper metabolism) is indicated by elevated urinary copper levels and reduced copper levels in blood serum. Hodgkins disease (cancer of the lymph nodes) is associated with elevated serum copper levels, and chronic lead poisoning causes elevated hair, blood and urine levels.

As early as 1942, it has been recognized that body tissues are constantly absorbing and excreting chemical constituents and are in a state of dynamic equilibrium. Hair is an exception. Unlike other tissues, hair is a metabolic end product that incorporates trace elements into its structure during its growth. Some 25 years ago, it was suggested that hair functioned as a minor excretory organ for arsenic and possibly other metals.

During the growth phase of a hair, matrix cells of the hair follicle show intense metabolic activity and produce hair at a rate of approximately 0.4 mm/day. Developing hair is exposed to the metabolic environment for a relatively short period of time. As a growing hair approaches the skin surface, its outer layers become hardened and relatively impermeable—thereby sealing in metabolic products accumulated during its formation. The trace element composition of the hair reflects the composition of the medium from which it was formed. In this way, hair provides a historical record of the trace elements associated with normal and abnormal metabolism, as well as a record of trace elements assimilated from the environment.

The popularity of hair as a biopsy tissue is largely due to the ease with which samples may be collected, and the stability of the samples after collection. In many early studies on trace element levels in hair, samples were collected in barber shops and beauty salons rather than in clinics and in laboratories. Some of the work from Japan is based on samples collected by combing. Much of the current work, however, uses samples collected from the back of the neck cut close to the skin, or samples cut close to the scalp at several sites on the head. To eliminate sur-

face impurities, sample preparation usually begins with washing in an organic solvent followed by detergent solution and rinsing with high purity water. No washing procedure has yet become universally accepted.

Trace element levels of hair are frequently measured by either neutron activation analysis or atomic absorption spectrometry. Neutron activation analysis has the advantages of requiring little sample preparation beyond washing, and it provides multi-element determinations from the same sample. Atomic absorption spectrometry requires complete chemical digestion of the hair sample prior to measurement, and this technique is capable of measuring only one element at a time. Nonetheless, instrumentation for atomic absorption spectrometry is readily available in most laboratories, and data obtained by atomic absorption spectrometry are as reliable as those from neutron activation analysis.

Normal values for trace element levels are established by analyzing hair samples collected from healthy volunteers living under similar environmental conditions. In actual practice, it is difficult to find a group of healthy people living under uniform, and closely regulated, conditions. Previous studies have used hair samples collected from cadets at the U.S. Air Force Academy, midshipmen at the U.S. Naval Academy and convicts who had served at least six months at either of two Michigan State Prisons. Once normal values for trace elements in hair are established, it is then possible to seek correlations between abnormal levels and disease states or environmental conditions. In making such correlations, however, it is necessary that the control and test populations be matched as closely as possible with respect to race, sex, age, dietary habits, etc.

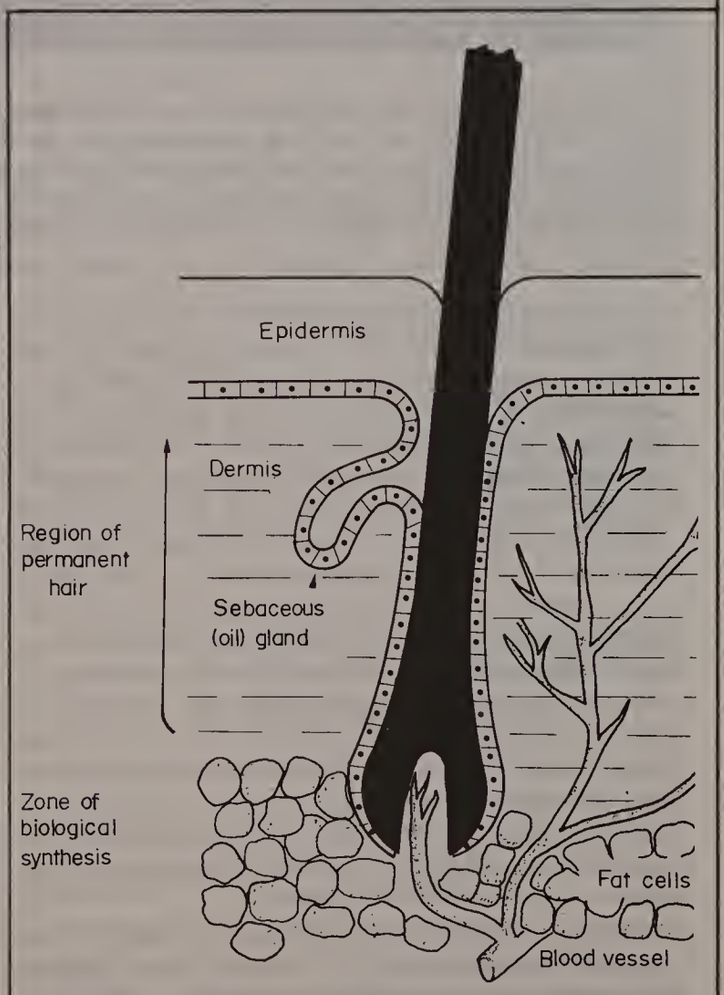
A firm correlation has been established between lead levels in hair and appearance of lead poisoning symptoms. The determination of lead in scalp hair has been suggested as a valuable diagnostic test for mild lead intoxication when other clinical or laboratory information is of questionable diagnostic value.

Lead levels of hair have been found to vary with environmental exposure. Canadians living near metal smelters were found to have median hair lead levels of 48.5 ppm, far in excess of levels measured for people living in rural (9.1 ppm) or urban (15.3 ppm) areas of the same country. Studies in Canada and elsewhere indicate that hair levels of most toxic elements are generally found to be higher among people living near metal refineries. People exposed to environmental arsenic in Czechoslovakia were reported to have elevated hair arsenic levels, as did Dutch residents of an industrial area where arsenic had been released into the environment. Such studies show a relationship between the levels of trace elements in the hair and environmental exposure, but they do not provide insight into the distribution of these elements in other body tissues and organs or the metabolism of these element in the human body.

Among the classic uses of hair for the evaluation of elemental poisoning was the identification of high arsenic levels in the hair of the Emperor, Napoleon Bonaparte. Based on neutron activation analysis of several authenticated hair samples, it seems reasonably certain that Napoleon ingested excessive amounts of arsenic during the period between 1816 and 1821. Some analysts interpret the elevated arsenic levels as a firm indication that he was poisoned: others suggest that the elevated arsenic levels resulted from the use of arsenic-containing medications at sub-toxic doses.

Studies of several toxic elements have established that abnormally high levels in human hair reflect a period of ingestion. One study investigating public drinking water supplies in California found a direct relationship between the arsenic level of potable water supplies and arsenic levels in the hair, blood and urine of the consumer. It cannot be argued that the relationship was due to external deposition of arsenic on the hair during bathing, as the corresponding blood and urine arsenic levels confirm that the hair was functioning as an excretory organ.

By measuring mercury levels in hair as a function of distance from the scalp, the onset and termination of mercury ingestion (at sub-toxic amounts) could be identified among Iranian villagers. With the period of exposure having been determined, the source of mercury was then traced to bread made from grain dressed with a mercurial fungicide.



Hair is formed as a metabolic end product in follicles beneath the skin surface. During growth of hair of a hair, trace elements are incorporated from the bloodstream. Once the growing hair approaches the skin surface, its outer layer becomes hardened and impermeable—permanently encasing its elemental content in a continuous record.

A close-up of a human hair fiber (about 900X magnification) shows its scaly surface. Chemical constituents of shampoos, lotions or smoke can be deposited in the hair and bind to its surface. These constituents can confuse the chemical analyst looking for real deficiencies or elevated levels of metabolic products within the hair. An effective procedure for washing hair samples needs to be developed, and then adopted universally (*photograph courtesy of the author*).

The zinc level of the hair has been used to monitor zinc deficiency in man. Zinc-deficient Egyptians were found to have a zinc hair level (54 $\pm$ 6 ppm) that is approximately half that of normal Egyptians, and well below the normal range of 150 - 190 ppm. Oral zinc sulfate therapy alleviated the clinical symptoms of zinc deficiency, and the hair zinc levels increased to normal. On the other hand, no significant differences were found between zinc hair levels of malnourished Zambian children and a healthy comparison group. Similarly, correlations between nutritional status and hair zinc levels were not found in 430 Thai children. It appears that the difficulty in relating elemental levels in the hair with nutritional status results from a failure to differentiate between *general* malnutrition and dietary deficiency of *specific* minerals. Elemental levels of the hair appear to reflect concentrations of specific elements in the diet.

There is much enthusiasm about the use of trace element determinations in the hair as a medical diagnostic tool. Adult diabetics have decreased zinc levels in the hair while children with diabetes show hair chromium levels below normal. Information such as this has contributed to the recognition that adult-onset diabetes is a different disease from juvenile-onset diabetes. A range of other diagnostic possibilities were reported at the Second Human Hair Symposium (held during the fall of 1978 in Atlanta). These would utilize the relationship between low hair sodium levels and celiac disease, low hair magnesium levels and phenylketonuria, low hair chromium levels and juvenile-onset diabetes, and elevated hair sodium levels and cystic fibrosis. Recently, it has been reported that the hair of multiple sclerosis patients is lower in selenium than the hair of normal subjects, and such differences may be of value in diagnosing this disease.

In addition to diseases of the body, diseases of the mind have been related to trace element levels in the hair. Recent work at the University of Aston in Birmingham shows elevated iron and lead levels and depressed cadmium and manganese levels in the hair of 37 patients with schizophrenia.

While many laboratories enthusiastically accept the use of scalp hair as a biopsy tissue, several serious questions remain. Before trace element levels in scalp hair become an acceptable diagnostic indicator of mineral metabolism, additional work is required in four specific areas: (1) normal values showing a narrow range must be established, (2) sample collection and sample preparation procedures must be standardized, (3) trace elements incorporated into the hair from within the body (endogenous) must be differentiated from contamination by external (exogenous) sources, and (4) standard reference materials must become available to allow laboratories to establish quality assurance programs.

In a recent survey of the literature, we found that so-called "normal values" reported for zinc and copper in scalp hair often differed by a factor of two, and sometimes as much as four-fold. Another tabulation of "normal values" shows a three-fold difference in the range of average copper levels

reported for hair (from 11.6 - 32 ppm), and a four-fold range for average zinc levels (99 - 450 ppm). Similarly, values compiled by the International Atomic Energy Agency show differences of two-fold for mean copper and zinc levels in hair. Laboratories reporting these widely-varying values have, for the most part, obtained good precision in their own test results. The apparent lack of agreement between laboratories probably originates from the different procedures used for sample collection and preparation. It is also likely that the "normal values" for trace element levels in hair show much wider regional variations than do measurements of blood levels.

The trace element content of a normal hair fiber may be as much as ten times greater at the proximal end (near the skin) than at the exposed (distal) end. While the reasons for such a concentration gradation are subject to debate, its existence may account for some of the inconsistencies in mean values reported for trace element levels. Early studies used hair samples collected by local barbers, and possibly only distal ends were sampled and analyzed. More recent work using hair samples taken near to the scalp may give consistently lower values. Fortunately, most current researchers have agreed to use samples taken close to the scalp. Before recommending that new additions be accepted into the literature, most reviewers require careful descriptions of sampling procedures.

Most of those involved in the determination of trace elements in hair agree that samples should undergo preliminary cleaning to remove surface contamination, but no standardized procedures have been universally accepted. Some laboratories wash hair samples in non-polar solvents to ensure removal of surface dust particles. Others use dilute acids as wash media, which completely remove ionic species absorbed on to the surface of hair fibers. The IAEA is currently urging adoption of a standard acetone - water - water - water - acetone washing procedure.

The washing procedures are intended to remove exogenous trace elements from the hair. Many studies have been undertaken to evaluate the efficiency of such procedures, but none was able to clearly differentiate between exogenous and endogenous trace elements. This inability to distinguish trace elements from external sources and those in the hair fiber presents a serious problem. A pre-diabetic with depressed hair zinc levels may appear normal due to zinc residue from topically-applied zinc pyrithione, an active ingredient in anti-dandruff shampoos. Similarly, a normal individual may appear to be suffering lead intoxication after application of a lead-acetate-containing cosmetic used to darken greying hair. Increased hair copper levels have been reported in individuals who swim in a pool where copper sulfate is used for algae control. Such exogenous sources of trace metals must be known before conclusions can be confidently based on trace metal determinations in scalp hair. If no procedure proves itself able to differentiate exogenous trace elements, it may be necessary to interview subjects whose hair is being analyzed.

Both the U.S. National Bureau of Standards and the International Atomic Energy Agency have prepared human hair samples for inter-laboratory comparisons. No standard reference materials are available at present, but with further experience, these will very likely become available in the near future.

Even though "normal values" for trace elements in hair are not firmly established, and even though exogenous trace elements can lead to erroneous conclusions, trace element determinations in human scalp hair have become commercial ventures. At present, there are at least three commercial laboratories in the U.S. specializing in hair analysis. These laboratories report the results of their determinations to individuals submitting hair samples. The laboratories draw no conclusions from their measurements: they leave the interpretations to physicians, dieticians, or others seeking such data.

The determination of trace element levels in human scalp hair shows promise of becoming an adjunct to the more traditional blood and urine analyses. Continued interest and activity in the use of hair as a biopsy material will establish the place of this approach as a probe for the evaluation of trace elements in the body.

Trace Element Levels in Hair as Potential Diagnostic Aids

CYSTIC FIBROSIS
elevated sodium levels

CELIAC DISEASE
depressed sodium levels relative to potassium

DIABETES, ADULT-ONSET
depressed zinc levels

DIABETES, JUVENILE-ONSET
depressed chromium levels

HYPOGLYCEMIA
elevated calcium levels, depressed potassium levels

HYPOTHYROIDISM
elevated zinc levels, depressed copper levels

HYPERTENSION
elevated cadmium levels

MONGOLISM
depressed calcium, copper and manganese levels

MULTIPLE SCLEROSIS
elevated sodium levels, depressed potassium levels, depressed selenium levels

PHENYLKETONURIA
depressed magnesium levels

RHEUMATOID ARTHRITIS
depressed magnesium levels

SCHIZOPHRENIA
elevated iron and lead levels, depressed manganese and cadmium levels

Supplies of aromatic chemicals hinge on coal, wood and waste

In the chemical industry, aromatic hydrocarbons are indispensable building blocks for the synthesis of plastics, fibres, rubber, dyestuffs, insecticides, herbicides and pharmaceuticals. Until the advent of petrochemistry based on oil and gas, coal had been the only source of basic aromatic chemicals for more than 100 years. Because of the decline in proven world reserves of petroleum and natural gas, and the rising world demand for energy and chemical resources, coal must again assume its former prominent role as a source of energy, fuel and chemicals—especially aromatic chemicals. At the same time, other carbonaceous raw materials—biomass and organic waste—will likely acquire an increasingly important role as a source of aromatics. While these sources can compensate for declining availability of petrochemical-based aromatics, research is required to further develop and optimize non-petrochemical processes for producing, recovering and upgrading aromatic chemicals.

by Dr. Gerd Collin
Rütgerswerke AG

While the chemical industry will need new sources for all aromatic hydrocarbons and their derivatives, the development of non-petrochemical processes must focus on providing those compounds which are now being used on a commercial scale worldwide—benzene, toluene, xylenes and condensed aromatics.

The basic aromatic hydrocarbon benzene accounts alone for one-half the present 30 million tons/year of aromatic hydrocarbons that are consumed worldwide by the chemical industry. Benzene is mainly converted into styrene, phenol, polyamides and other important chemical intermediates. Toluenes, xylenes and condensed aromatic hydrocarbons each account for about one-sixth of total consumption. Toluene is dealkylated to produce benzene and used for the synthesis of polyurethanes and explosives; the xylenes are used to synthesize polyurethanes and plasticizers; and condensed aromatic hydrocarbons are utilized to make organic dyestuffs and pigments.

The relative demand for these aromatic chemicals leads us to consider which raw materials might be able to displace petroleum and natural gas as their source. The most obvious candidate is coal.

Coal is a macromolecular organic raw material. Despite extensive study, its chemical structure has not yet been fully clarified. A number of molecular coal models have been produced, exemplified by the one sketched by Given in 1960 and presented here. The model shows aromatic, phenolic, heterocyclic and hydrogenated ring systems with aliphatic chain bridges. Heat or chemical action can break the coal molecule at these bridges and release small aromatic molecules.

Four processes may be used to split the coal molecule:

Pyrolysis (carbonization) forms coke, with byproducts of benzene, phenols and condensed aromatics.

Extraction (solvolysis) by solvents or supercritical gases yields condensed aromatics.

Catalytic hydrogenation produces aromatic coal oils, which contain benzene and its homologues, phenols, and condensed aromatics.

A fourth conversion process, **gasification,** produces a mixture of carbon monoxide and hydrogen (synthesis gas) which can be used indirectly for the synthesis of aromatic hydrocarbons.

Let us first consider coal pyrolysis, which is already meeting 25% of the world demand for aromatic hydrocarbons, including 15% the demand for benzene and 98% the demand for condensed aromatics. Coal pyrolysis is utilized primarily to produce metallurgical coke, and thus, production of aromatics by this process is linked with the demands of the iron and steel industry. At present, some 350 million tons of coal coke are produced annually on a world-wide basis. Coal is converted to coke with a yield of about 80%. Also produced are volatile byproducts—including 1% crude benzole and 3% high-temperature coal tar. Total production of these unrefined products amounts to about 20 million tons annually.

About 130 refineries are presently utilizing benzole and coal tar as a source of aromatic compounds. As would be expected, these refineries are located mainly in industrialized countries which are large steel

producers. About 30% of world capacity is located in Western Europe, 27% in Eastern Europe and the USSR, 22% in North America, and 20% in South-East Asia. Curiously, the geographical distribution of coal chemical refineries differs significantly from the distribution of petroleum resources. Coal tar and crude benzole are available in countries having little petroleum. Perhaps this is responsible for the relatively high proportion that is used as a source of chemicals, rather than burned to provide energy. Another explanation is the extraordinarily high content of aromatic compounds in the hydrocarbon byproducts of coal pyrolysis (as one would expect from looking at coal models).

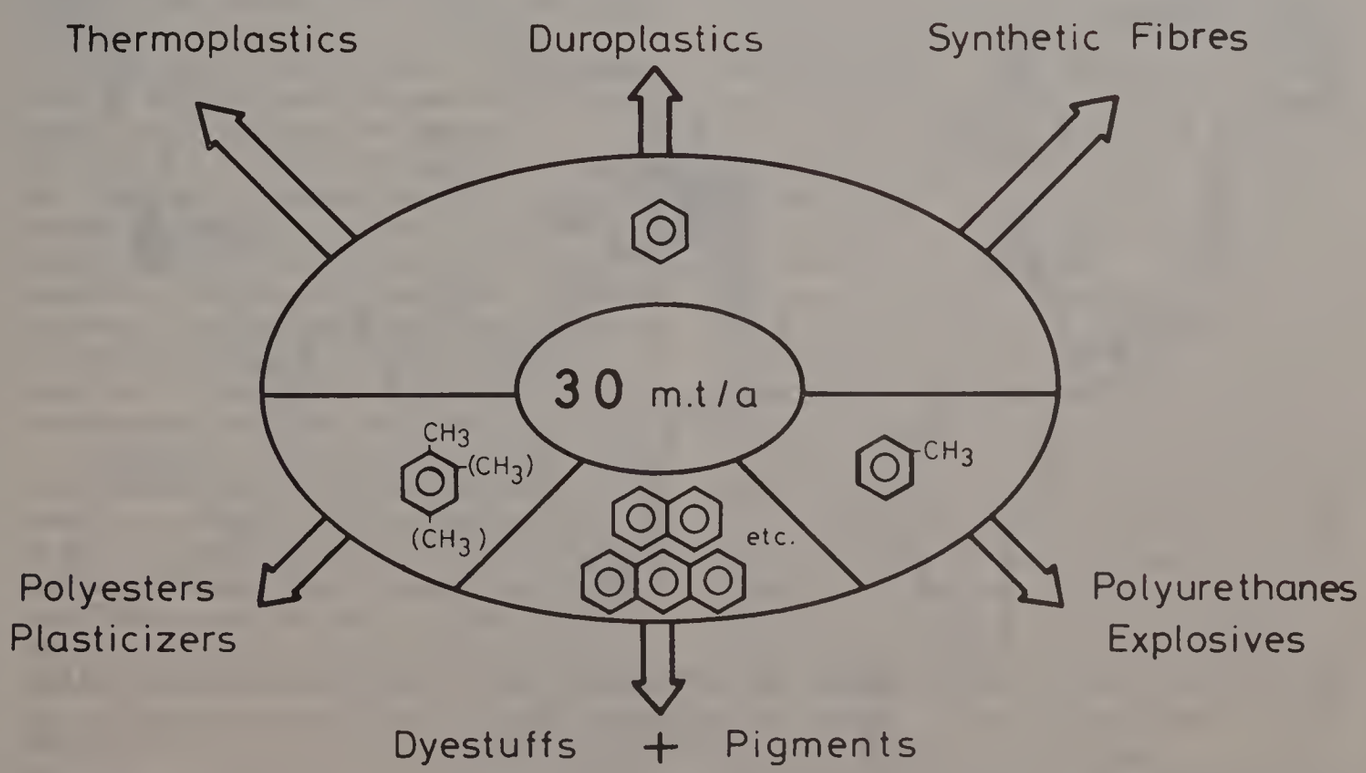
Both coal tar and crude benzole are composed almost entirely of aromatic compounds. Crude benzole contains only about 5% non-aromatics; high-temperature coal tar less than 1%. The main constituents of crude benzole are benzene (about 65%) and toluene (15%), the remainder consisting of xylenes and higher-boiling benzene homologues. High-temperature coal tar contains predominantly unsubstituted condensed aromatic hydrocarbons. The main bicyclic aromatic constituent is naphthalene, with a content of 10%. Coal tar also contains the tricyclic aromatic hydrocarbons phenanthrene and anthracene.

The wide range of aromatic chemical products present in crude benzole and coal tar must be separated and recovered if they are to be utilized. Modern tar and benzole refining technology is a combination of 7 unit operations:

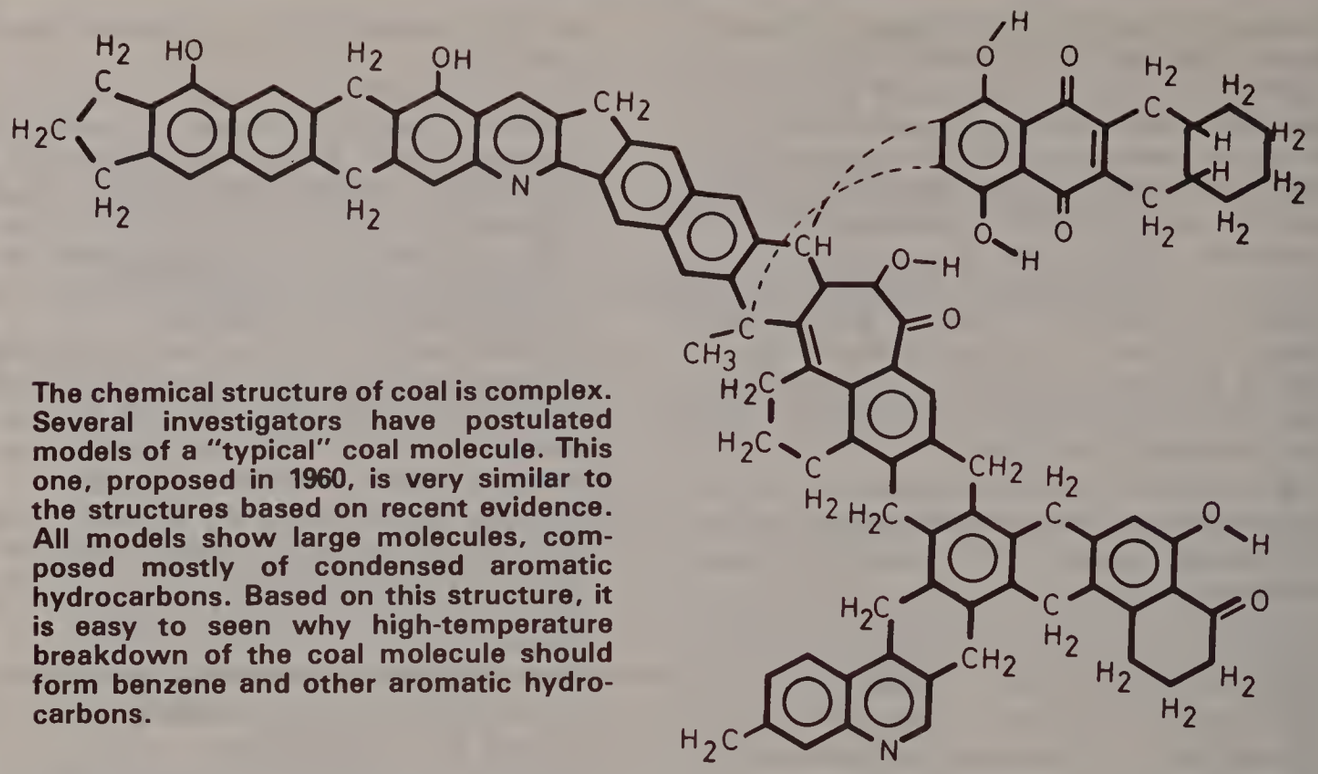
(1) Distillation separates crude tar into primary fractions.
(2) Crude benzole undergoes a catalytic hydrorefining. This is followed by extractive distillation for recovery of pure benzene and its homologues (to be used primarily for the synthesis of plastics and fibres).
(3) Crystallization allows the recovery of pure condensed aromatic hydrocarbons and non-polar heterocycles (such as naphthalene, anthracene, acenaphthene, carbazole and pyrene). These compounds are utilized for the synthesis of dyestuffs, formulation of wood preservatives and (following further pyrolysis) for producing carbon black fillers and pigment black.
(4) Extraction with base and acid recovers the polar aromatic compounds (phenols and heterocyclic ring compounds containing nitrogen). These are raw materials for thermosetting resins, insecticides, herbicides, and pharmaceuticals.
(5) Catalytic polymerization of light oils (with Friedel-Crafts catalysts) yields thermoplastic aromatic indene-coumarone resins for the formation of rubber, adhesives, paints and plastics. plastics.
(6) Thermal polymerization converts coal tar pitch, the residue from primary distillation of tar, to electrode pitch. And finally,
(7) Pyrolysis of pitch produces a low-ash electrode coke. This product is used (together with electrode pitch) to make carbon anodes used in electric aluminium smelters and for graphite electrodes used in electric steelmaking furnaces.

Application of all these operations allows a wide range of aromatic chemical products to be produced. However, this can only be achieved on an economic basis when large quantities of coking byproducts (at least 0.3 million ton/year of crude benzole and 0.5 million ton/year of crude tar) are available for processing in centralized production plants.

The distribution of aromatic compounds produced by coal pyrolysis reflects the carbon/hydrogen ratio



Of the 30 million tons/year worldwide consumption of aromatic hydrocarbons, benzene accounts for half. It is mainly converted into styrene, phenol and other important intermediates in the plastics and synthetic fibre industry. Toluene, xylenes and condensed aromatics (naphthalene, anthracene, etc) each account for about one-sixth of the total demand.



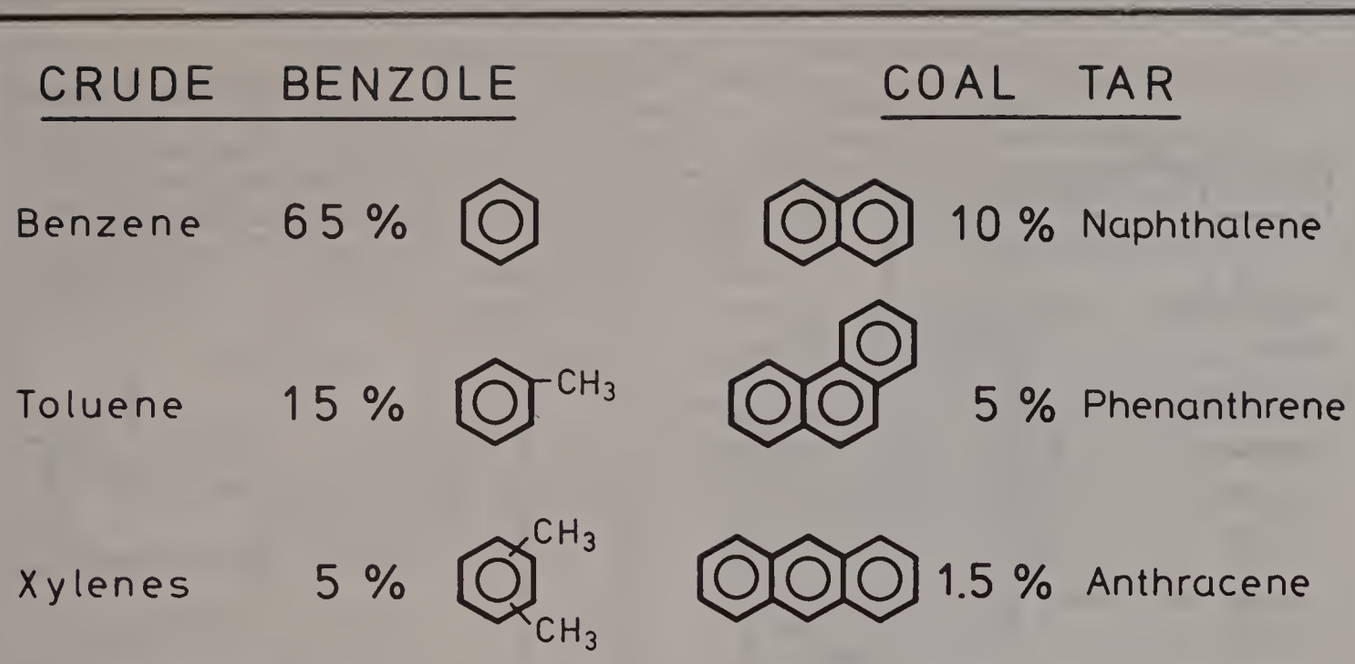
The chemical structure of coal is complex. Several investigators have postulated models of a "typical" coal molecule. This one, proposed in 1960, is very similar to the structures based on recent evidence. All models show large molecules, composed mostly of condensed aromatic hydrocarbons. Based on this structure, it is easy to seen why high-temperature breakdown of the coal molecule should form benzene and other aromatic hydrocarbons.

of the coal, which is generally much higher than is found in petroleum. Thus, coke byproducts are able to provide a large share of industrial demand for aromatics with a high carbon content. The condensed aromatic hydrocarbons naphthalene and anthracene—with carbon/hydrogen ratios of 1.25 and 1.4—are obtained almost exclusively from coke-oven tar. Benzene, which has a carbon/hydrogen ratio of exactly 1.0, is present in benzole to the extent that it provides 15% of world demand. Toluene and xylenes (benzene homologues with methyl groups substituted for hydrogen) have carbon/hydrogen ratios of less than 0.9, and are currently obtained almost exclusively from petrochemical sources.

In this way, petrochemistry and coal pyrolysis are able to augment each other to meet the demand for aromatic chemicals. However, aromatics obtained by coking are unlikely to provide a greater share of world demand, since the output of benzole and tar from coal carbonization is linked with the production of coke for the iron and steel industry.

Other coal conversion processes seem likely to make further contributions towards broadening the non-petrochemical raw material base for aromatic

Since benzole and coal tar are byproducts of coke production, it is not surprising that these aromatic-rich mixtures are produced and refined mostly in steel-producing industrialized countries. Thus, the geographical distribution of coal chemical refineries is very much different from the distribution of petroleum resources.



Benzole and coal tar are composed almost entirely of aromatic compounds. When benzole is refined, it yields mostly benzene, toluene, xylenes and higher benzene homologues. Coal tar is a more viscous material, consisting of condensed aromatic molecules with higher melting points: naphthalene, phenanthrene and anthracene for example.

chemicals. Let's now turn to the second of the possible coal conversion processes: coal extraction (with solvents or supercritical gases). When contacted by hot solvents, the huge hydrocarbon molecules which form the structure of coal decompose. The coal normally swells and—depending upon circumstances—may disintegrate and disperse, with smaller fragment molecules dissolving in the solvent. The yield and composition of these soluble compounds depend upon the type of coal, the extraction procedure and the nature of the solvent.

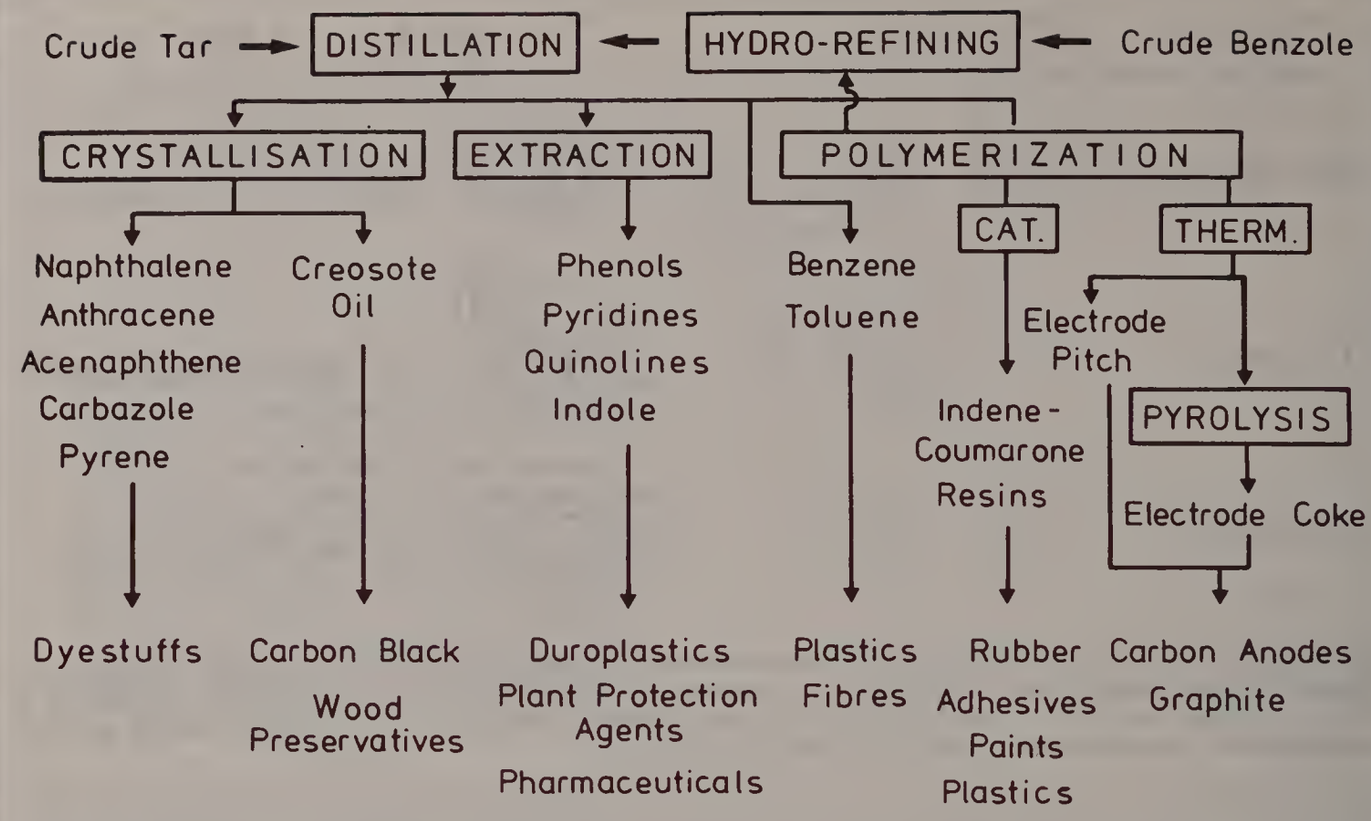
Solvolysis, or "extractive disintegration", refers to the action of *solvents* on coal at temperatures around 300 - 400°C, at which coal decomposes. The yield of hydrocarbons extracted by the hot solvent increases progressively with temperature up to about 400°C. Above this temperature, pyrolytic condensation reactions in the coal make it less soluble. Suitable solvents for solvolysis are anthracene oils from coal tar, tetralin and recycled hydrogenated anthracene oil. These act as hydrogen donors at temperatures around 400°, and provide greatest solubility of extracted material. When high-volatile bituminous coal is treated, the extract yield can be 80% or more of the coal mass. The undissolved residue must be separated by pressure filtration to obtain a mineral-free coal extract. This filtration process requires elaborate equipment and may necessitate further addition of solvents.

Separation of undissolved residue is much simpler when *supercritical gases* are used to extract soluble hydrocarbons. This technique, first used for deasphalting petroleum fractions, has been investigated in particular by the British National Coal Board. At temperatures about 400 - 450°C and a pressure of 100 - 200 atmospheres (10 - 20 MPa), toluene or light coal-derived liquids act as supercritical gases, extracting 30 - 50% of high-volatile bituminous coal into the vapour phase. The extract is recovered merely by reducing the pressure. The release of pressure lowers the density of the extractor gas and causes the extract to precipitate. A disadvantage of supercritical gas extraction is that extraction yields are lower than may be achieved with conventional solvolysis.

Coal extracts obtained with solvents or supercritical gases have a high aromatic content, but are composed largely of high molecular weight bituminous materials. To obtain useful basic hydrocarbons, the extracts must undergo further processing by catalytic hydrocracking. Upgrading methods developed by the National Coal Board have provided extremely good yields, up to 90%. Hydrogenated extracts produced during research trials contained 7% (with solvolysis) and 12% (with supercritical gas extraction) benzene and homologues, up to 25% other aromatics, and up to 50% hydroaromatics. Paraffins and cycloparaffins are contained in amounts up to 40%.

Direct conversion of coal to low molecular weight aromatic compounds can be accomplished by catalytic hydrogenation. The reaction with hydrogen breaks apart the chemical structure of coal and upgrades the hydrogen content of the product molecules (in other words, reduces their carbon/-hydrogen ratio). Coal particles are fed into the hydrogenation reactor as a slurry suspended in heavy oils. The oils are subsequently recirculated. One high-pressure catalytic hydrogenation process using high-volatile bituminous coal produces a distillate oil (with a boiling range up to 300°C) in 45% yield. The process operates at about 450°C. Hydrogen consumption is about 6% the mass of the coal feed. Some 60% of the product consists of aromatics and partially hydrogenated aromatics. The aromatic yield can be further increased by catalytic reforming. Commercial-scale coal hydrogenation plants are now planned for construction in the Federal Republic of Germany and the USA, promising to provide the chemical industries in these countries with a new non-petrochemical source of aromatics. Before this happens, however, commercial-scale coal gasification plants may already be in operation.

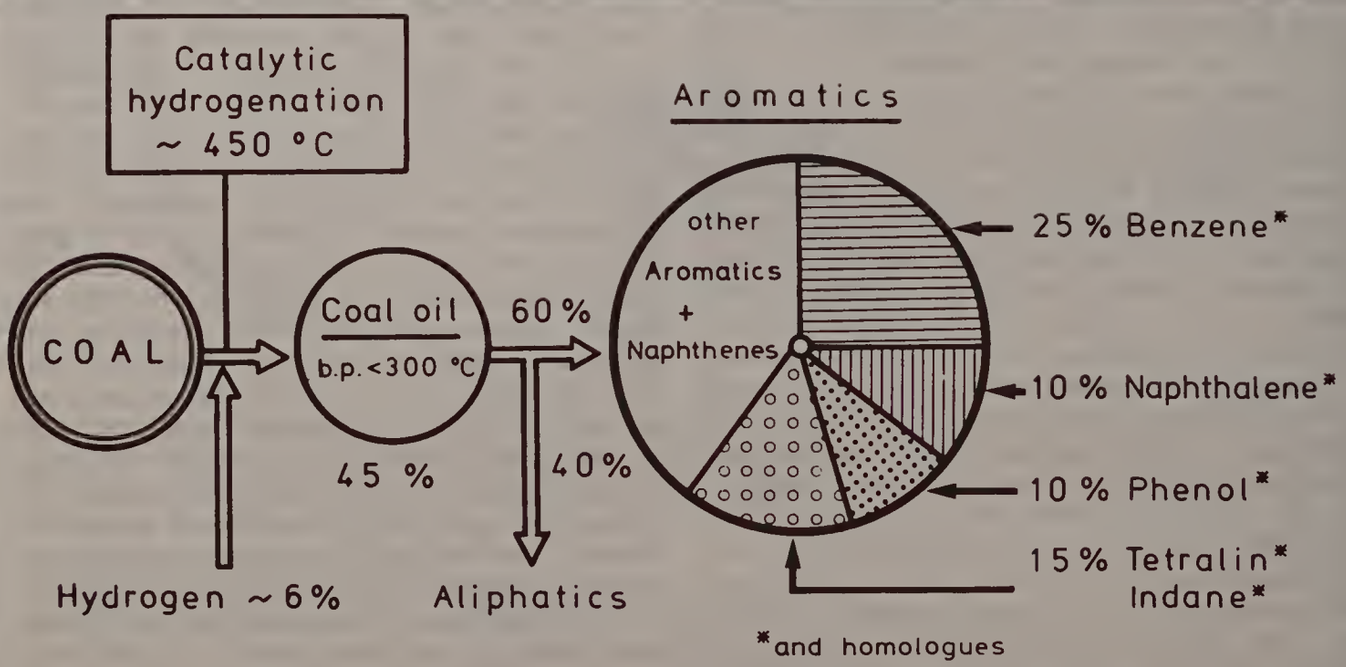
Coal gasification will provide the chemical industry with a different type of non-petroleum raw material source, synthesis gas (a mixture composed mainly of hydrogen and carbon monoxide). For a long time, it has been known that synthesis gas can be



A wide range of aromatic chemical products can be produced by refining crude benzole and coal tar. This requires a series of separation and upgrading steps. Complete processing of the crude material is only economically feasible in large centralized refineries, for which large amounts (about a million tons of benzole and tar) must be available.

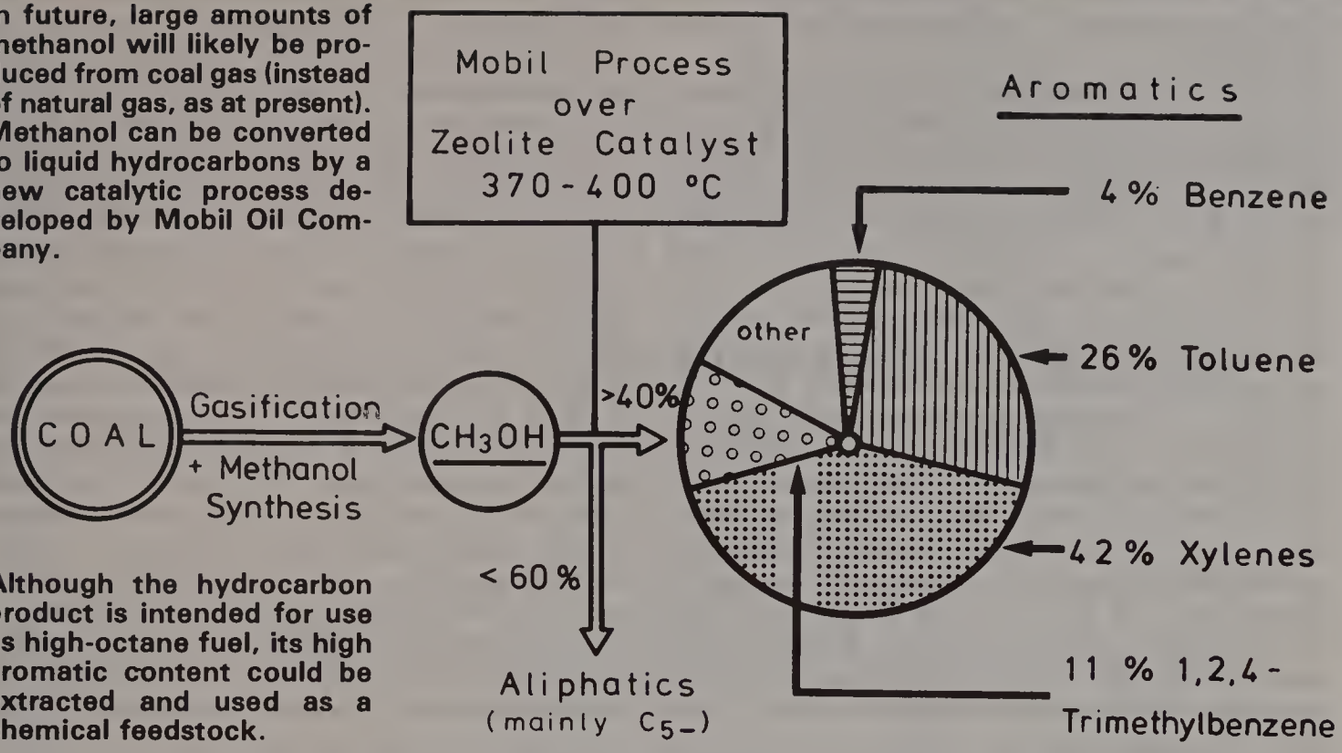
condensed to form aliphatic compounds: synthesis gas has long been used to make methanol, and is the feedstock for the Fischer-Tropsch process now used to make synthetic motor fuel from coal in South Africa.

Development of new types of zeolite catalysts now provides the opportunity for methanol (made from synthesis gas) to be converted into a range of *aromatic* compounds. This process has been developed particularly by the Mobil Research and Development Corporation. In the reaction, methanol is first converted to a dimethyl ether intermediate. This reacts to form olefins, which produce aromatic compounds in the final stage of the reaction. The reaction takes place at temperatures of 370 - 400°C in a fixed or fluidized bed. The aromatic content increases with residence time in the reactor, and can comprise over 40% of the hydrocarbon product and over 90% of the C_5^+ liquid fraction. The main aromatic constituents are toluene, the three xylene



Reaction with hydrogen breaks apart the chemical structure of coal, and produces low molecular weight aromatic compounds. The coal oil product contains 60% aromatics and partially hydrogenated aromatics. The main drawback of catalytic hydrogenation is its consumption of hydrogen, whose production is expensive and energy-intensive. Some of the hydrogen may be supplied by gasification of byproduct char.

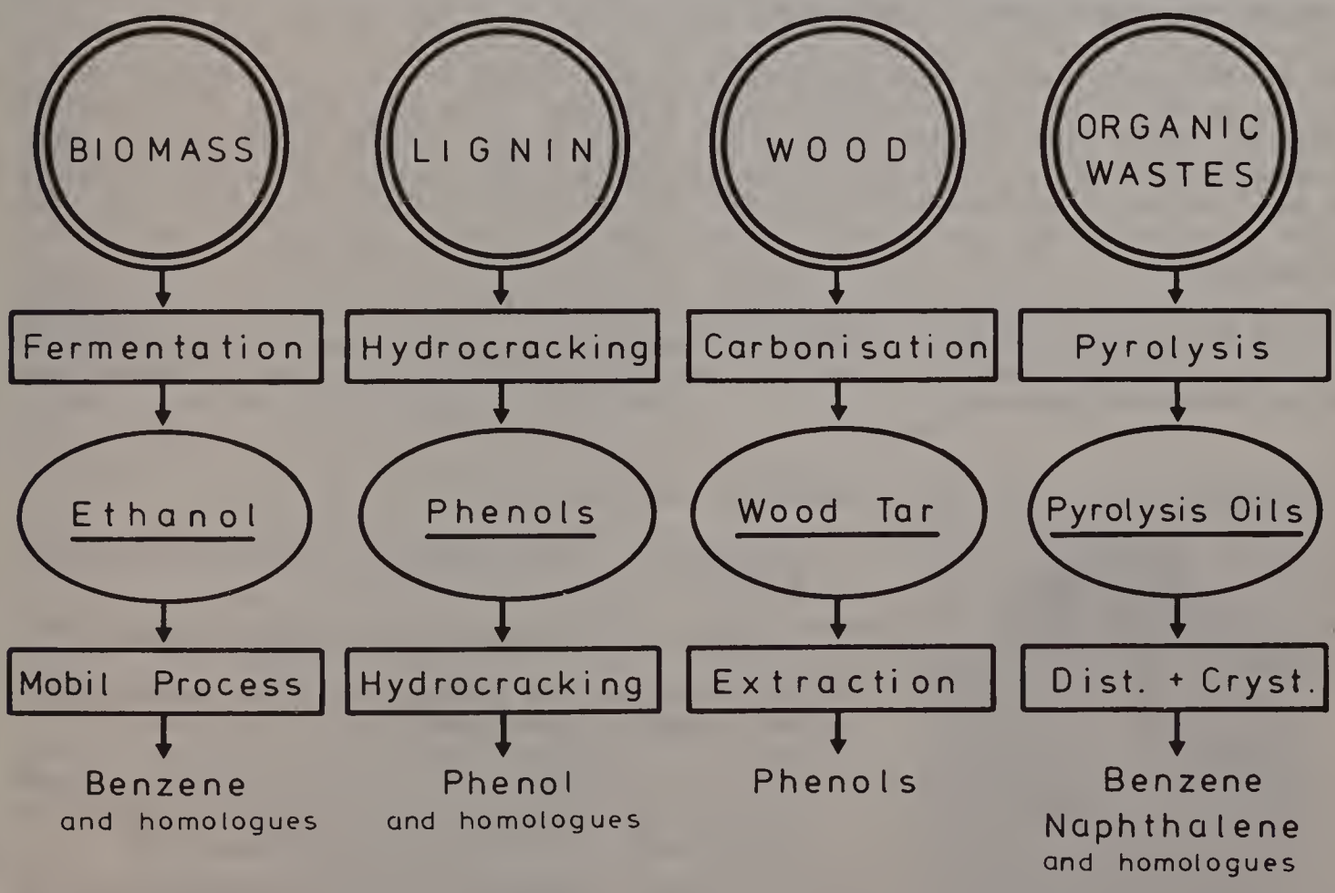
In future, large amounts of methanol will likely be produced from coal gas (instead of natural gas, as at present). Methanol can be converted to liquid hydrocarbons by a new catalytic process developed by Mobil Oil Company.



Although the hydrocarbon product is intended for use as high-octane fuel, its high aromatic content could be extracted and used as a chemical feedstock.

isomers, and 1,2,4-trimethyl benzene. Only minor quantities of condensed aromatic hydrocarbons are formed under normal reaction conditions. While the process has been developed to produce high-octane hydrocarbon fuels, the product mixture could naturally be used as a source of aromatic compounds for the chemical industry.

Instead of methanol, the Mobil process could also use ethanol as the starting compound, thereby allowing aromatic hydrocarbons to be made from fermented vegetable matter. This provides a new chemical pathway for obtaining aromatics from renewable resources. Fermentation of carbohydrate-rich plants to produce ethanol is being undertaken on a rapidly expanding scale (particularly in tropical countries with abundant renewable biomass, such as Brazil). Although mainly intended as a source of fuel, fermentation ethanol could perhaps play a



Renewable resources can also serve as a source of aromatic chemicals. Vegetable matter can be fermented to ethanol, and this converted to aromatic-rich liquid hydrocarbons by the Mobil Process. Lignin, a waste product of papermaking, could be hydrolized to produce phenols. When wood is pyrolyzed to make charcoal, it ylelds a byproduct tar—much the same as coal pyrolysis. Waste plastics, scrap tyres and other industrial wastes can also be pyrolyzed, producing oils which consist almost entirely of aromatic hydrocarbons.

significant role as a raw material for chemical manufacture.

All the methods mentioned so far produce aromatic chemical feedstocks as byproducts of a few commercial-scale processes, e.g. metallurgy or energy and fuel production. As raw material prices continue to rise, it will become increasingly economic for the chemical industry to utilize the byproducts and wastes from other industrial conversion processes. Wood pulp, for example, could be developed as a potential source of aromatics. Until now, wood pulp has generally been considered only as a source of cellulose. The aromatic portion of wood, lignin, is separated from cellulose during paper manufacture, and is generally discarded. Of the approximately 30 million tons/year of lignin which are obtained in this way, only about 5% is utilized. About 75% is burned and 20% is discharged into water courses as a pollution effluent. Yet, hydrocracking of lignin could provide a crude phenol fraction of about 50% yield. This would contain phenol homologues as the main components, which could be converted to phenol itself with further hydrocracking.

Another possible source of high-phenolic mixtures is the carbonisation of wood. Pyrolysis of wood is employed to produce charcoal for fuel, activated charcoal and (particularly in South America) iron ore reductant for use in blast furnaces. The process also yields wood alcohol, pyroligenous acid and 10 - 20% of the dry wood mass is obtained as wood tar (which contains about 40% phenols). The current total production of charcoal, some 5 million tons per annum, represents a potential source of phenols of the order of one million tons per annum.

Organic wastes are yet another possible source of organic raw materials. Waste plastics, scrap tyres and numerous industrial wastes have a high organic content which can be converted with up to 50% yield to hydrocarbon pyrolysis oils. These oils are extensively aromatized at pyrolysis temperatures around 700°C.

Pyrolysis of organic waste materials is being tested on a pilot scale in the USA, Japan and Federal Republic of Germany. Pyrolysis oils obtained from mixed thermoplastic wastes, car shredder wastes containing plastics, plastic and rubber-sheathed scrap cables, and scrap tyres have been found to contain 20 - 40% benzene, an average of about 20% toluene, 10 - 15% $C_{8/9}$ aromatics, 8 - 16% naphthalene and homologues, and 20 - 30% polycyclic aromatics and involatile pyrolysis resins. The content of aliphatic hydrocarbons is less than 2%. Such pyrolysis oils can be economically processed in existing or future refineries to obtain basic aromatic hydrocarbons similar to the by-products of coal carbonisation.

It is currently estimated that more than one million tons/year of waste plastics are discarded in the Federal Republic of Germany, in addition to scrap tyres and other organic polymer material. When (and if) plans are implemented to separate organic waste from domestic refuse, it should be possible to recover at least half a million tons of aromatic pyrolysis oils. Based on current data for consumption of aromatic chemicals, refining of these pyrolysis oils could provide almost 10% the demand for benzene, 60% the demand for toluene, and 80% the consumption of naphthalene and its homologues. The organic component of domestic refuse could thus make an appreciable contribution towards meeting the demand for basic aromatic chemicals.

About the author:

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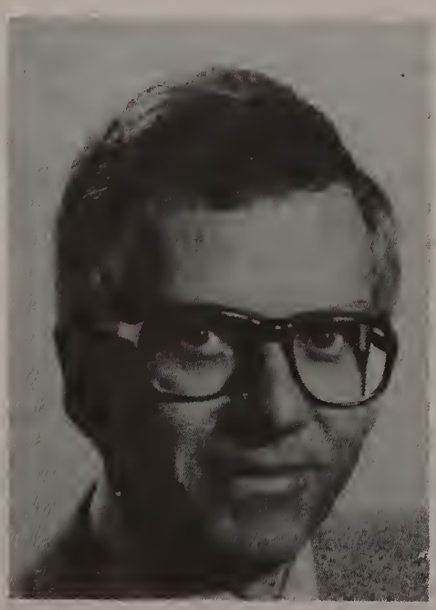

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A new definition of pH? IUPAC convenes a panel of experts for the acid test

To many chemists, pH is a quantity measured with a pH meter or indicator papers and hardly likely to become a controversial subject. Yet since 1977, serious challenges have been raised about the number and types of reference materials needed to define the pH scale. The controversy led to the convening of a conference of pH experts attended by delegates from 10 countries. The conference, held in Lisbon in June 1980, was organized by the members of two IUPAC Commissions. The Commissions on Electrochemistry and Electroanalytical Chemistry will weigh the recommendations made at the conference to decide if IUPAC needs to adopt a new definition of the pH scale. A proponent of the new definition and a participant on both Commissions, Dr. A. K. Covington provided background information for this report.

The concept of pH is unique among physicochemical quantities. Since it is defined in terms of hydrogen ion activity, it is not directly measurable. Fortunately, in the fairly dilute solutions that are generally used for pH measurements, the hydrogen ion activity can be related to its concentration using conventions based on Debye-Hückel theory, which are believed to be of fairly wide applicability.

An electrochemical cell may be constructed whose voltage is dependent upon hydrogen ion concentration, and this allows pH to be defined *operationally* (that is, in terms of the operation, or method, used to measure it). The cell consists of a platinum/H_2 electrode immersed in the solution, which is in contact (through a salt bridge forming a liquid junction) with a reference electrode (usually a mercury calomel electrode). Standard buffer solutions are used to standardize the cell voltage to correspond with the equivalent pH.

The controversy focusses on the number of standard solutions that are used to define the pH scale. Theoretically, if activity coefficients and liquid junction potentials remained constant the cell voltage should vary linearly with the pH of the test solution (with a slope of 2.303RT/F, or 59 mV/pH unit at 25°C). To define the pH scale, therefore only one reference point (pH at a specified concentration of hydrogen ion concentration) is needed.

Accordingly, in the single-standard scale, adopted in the UK, a pH value is assigned to one buffer solution, based on voltage measurements of cells without a liquid junction, assuming the convention for ionic activity coefficients is true for this one solution. pH values are then assigned to any number of secondary standard buffer solutions using the operational cell with a carefully-formed liquid junction. This approach makes no assumptions about the wide applicability of the convention for ionic activity coefficients, and any differences in liquid junction potential values from that of the primary standard are included in the assigned pH values.

In the multi-standard scale, the system developed at the US National Bureau of Standards, pH values are assigned to five or more buffer solutions based on voltage measurements of cells without a liquid junction, assuming the convention for ionic activity coefficients is valid for all the solutions. These solutions are then used to standardize operational cells. This requires the further assumption that the liquid junction potentials between the buffer solutions and the salt bridge solution (most commonly, 3.5 M KCl) are constant.

Most countries have followed the NBS multistandard pH scale, but there is no conformity in the number of standard reference materials or, in a few cases, in the concentrations at which they are to be used. While the US pH scale is based on 10 reference standards, Germany has 9, Poland has 7, France has 3, and the USSR has 7. These differences were pointed out in a report by a subcommittee of the IUPAC Commission on Physicochemical Measurements and Standards (published in *Pure & Applied Chemistry,* 50, 1978, p. 1485-1517). The present

The two conference representatives from the USA (Prof. R. G. Bates and Dr. R. A. Durst, in photo on left) and three representatives from the German Federal Republic (including Drs. F. G. K. Bauche and W. Melzer, in photo on right) opposed adoption of a new pH scale by IUPAC. Their views were not supported by most other conference representatives. The view through the camera lens and information for this article were provided courtesy of Dr. A. K. Covington, from whom further details are available.

IUPAC definition is based on NBS pH values, and recommends the use of 5 primary reference standards.

At about the same time as this subcommitte was writing their report, a joint meeting was held in Warsaw between the IUPAC Commission of Electrochemistry and Electroanalytical Chemistry. A majority of members of the two Commissions expressed themselves in favour, in principle, of a single primary standard. However, some members cast doubt on the use of potassium hydrogen phthalate as the single primary standard. Consequently, a research programme was begun to investigate whether this material was available with consistently high purity. This work was undertaken by Dr. A. K. Covington, a member of the IUPAC Commission on Electroanalytical Chemistry and the UK National Representative to the Commission on Electrochemistry, and his co-investigators. They developed a method of purity estimation and found that the pH of potassium hydrogen phthalate at 25°C was 4.005 instead of the accepted value of 4.008, and revealed that other revisions were needed as well for pH values between 45-65°C.

A subcommittee was appointed (consisting of Dr. Covington from the UK, and Drs. R. G. Bates and R. A. Durst from the USA) to consider these matters. They presented their findings to the two Commissions at the 30th IUPAC General Assembly in 1979 (held in Davos, Switzerland). They concluded that potassium hydrogen phthalate *was* suitable as a primary standard *if* a single primary standard scale were to be adopted. However, the US members of the subcommittee were not convinced that there was a need to change the pH scale definition. To resolve the issue, the two Commissions agreed that a conference of pH experts with world-wide representation was needed. Subsequently, the same subcommittee began arrangements for a conference in Lisbon, sending invitations to 85 national standards organizations, the International Standardization Organization, International Electrotechnical Commission and other international bodies known to be preparing documents on pH.

The conference representatives heard arguments in favour of the multistandard scale of the US National Bureau of Standards (presented by R. G. Bates) and for the British pH scale using a single standard (presented by A. K. Covington). The current state of pH standards recommended by various countries and international organizations was then reviewed. Among the countries represented, it was reported that China, the German Federal Republic, USA and Poland had multistandard scales, while a single primary standard scale is advocated in Australia, Italy, Netherlands as well as the UK. The Organisation Internationale de Métrologie Légale (OIML) listed 9 standards in their recent document, but did not distinguish between primary and secondary standards.

Conference representatives then discussed the relative advantages of the multistandard and single standard pH scale. It is impossible to summarize here the hours of discussion and argument. Ultimately, a vote was held on the resolution that "A single primary standard pH scale should replace the existing IUPAC multiple primary scale". The resolution was passed by 10 votes in favour, 7 against. An even more positive response was expresed for the second resolution that "The single primary standard adopted should be a 0.05 mole/kg aqueous solution of potassium hydrogen phthalate". It received 14 votes in favour and none against, with 3 abstentions.

These resolutions will be considered by the next joint meeting of the IUPAC Commissions on Electrochemistry and Electroanalytical Chemistry at the 31st IUPAC General Assembly in Leuven, Belgium in August 1981. IUPAC is, of course, not committed to accept the resolutions passed by the Lisbon conference.

A change in pH scale recommendations will have very little effect on pH measurements in industry,

most of which are at the level of precision of ± 0.05 in pH. Neither are there any implications for national metrological institutes, who will still be required to certify standard reference materials. There are some implications for the interpretation of pH measurements in terms of hydrogen ion activity or concentration. However, for the two principal areas where this is practised, the derivation of species concentration in body fluid or seawater, there are special problems arising from the high ionic strength of the media.

Standard terminology will bridge chemistry & engineering

In many subjects of vital importance to the chemical industry—toxicology, safe handling of chemical compounds, environmental pollution, and protection and conservation of resources—much could be gained by close cooperation between scientists and engineers. Yet, there is little interplay between chemists, chemical engineers, microbiologists and corrosion specialists in these areas.

The minimal interaction between scientists and engineers in most industrialized countries has paralleled the tradition for separate scientific and engineering societies. This is true on an international level as well, with IUPAC representing Chemistry Committees of National Science Academies, and various federations representing societies of engineers, material scientists and microbiologists in Europe, North and South America, and Asia.

Collaboration between IUPAC and international engineering organizations is suggested in the 2nd Information Newsletter prepared by the IUPAC Committee on Chemistry & Industry (COCI) in August 1980. Prof. D. Behrens, a member of the IUPAC CHEMRAWN Committee and the European Federation of Chemical Engineers, presents a survey of international organizations of chemical engineers, biotechnologists and corrosion specialists. He concludes that closer cooperation between IUPAC and chemical engineering organizations could prevent duplication of effort, and avoid overlapping interests. As a general guideline, he suggests that IUPAC concentrate its activities on those fields of applied chemistry which are mainly related to chemical products, and leave work on chemical processes to engineering organizations.

At the same time as the COCI Newsletter was in preparation, IUPAC President Zollinger was addressing the same issue in a panel discussion at the 5th IUPAC Conference on Physical Organic Chemistry in Santa Cruz (California, USA). He told the audience that their knowledge of physical organic chemistry could be applied by chemical engineers in industry. Since physical organic chemistry deals with chemical mechanisms on the molecular level, it is complementary to the macroscopic approach of chemical engineers. Together, physical organic chemistry and chemical engineering can augment each other in solving process and ecological problems in the most effective way.

Such cooperation, Prof. Zollinger explained, is only possible if physical organic chemists (and organic chemists) try to speak the same language as chemical engineers. They should not assume that others understand their own specialist language.

Another conference speaker, Prof. R. T. Morrison (co-author with R. N. Boyd of "Organic Chemistry", the most widely-used and influential organic chemistry textbook ever published in the USA) backs this viewpoint from his experience. He explained how the strategy of teaching undergraduate organic chemistry was revolutionalised within the last 20-30 years because of the systematization and categorization of chemical compounds. Before this, organic chemistry was an almost structureless assembly of 2-3 million different compounds. The situation was about the same as in inorganic chemistry before the periodic table had been elaborated. The systematization of organic chemistry enabled teachers and writers (like Prof. Morrison) to approach organic chemistry in an entirely new and more student-appealing way.

The discussion at the Santa Cruz conference highlights the need for clearly defined terminology acceptable to specialists in related fields. In this respect, Prof. Zollinger feels that publication of the "Glossary of Terms used in Physical Organic Chemistry" *(Pure & Applied Chemistry,* No. 8, 1979) has made a real contribution. So too does he commend present IUPAC efforts to establish a system of nomenclature for organic reactions. This, Prof. Zollinger feels, will be a major achievement not only for *nomenclature* in an absolute sense, but for *understanding* of organic chemistry. Perhaps this type of approach will help chemists to communicate more effectively with chemical engineers and other scientists.

Science & society in the classroom

A broad perspective on chemical education in the early 1980's is presented in an article written by Prof. D. J. Waddington, Secretary of the IUPAC Committee on Teaching of Chemistry. The article, appearing in a book just published*, explains the trends in chemical education discovered by 3 Committee members (Professors C.N.R. Rao, A. Kornhauser and D. J. Waddington) while compiling an anthology "Chemical Education in the Seventies". They found that increasing emphasis had been placed on basic principles during the period of active curriculum reform in the 1960's and 1970's. During this period, there were also determined efforts to include experimental work as an integral part of the chemistry curriculum.

In countries where this trend had begun early, doubts have now arisen about course content and teaching methods. The so-called "conceptual ap-

proach" has become particularly heavily criticized. Some critics believe that course content has become biased towards producing future chemists and has little appeal for non-science students. There is also much concern about laboratory work, for it may be less effective than course designers had anticipated. With rising costs and questions about laboratory safety, support for laboratory coursework may be undermined. Thus, chemical education enters the 1980's with doubts about present courses—doubts that will not be dispelled simply by writing new curricula. Many of the problems are fundamental to the teaching of chemistry.

One basic problem is the widespread antipathy toward science among young people in some countries. Its cause is not clear. Perhaps chemistry is regarded as too abstract, or its applications in daily life are not recognized.

In this respect, curricula developed in the 1960's and 1970's have failed with their inward-looking approach. These programmes have done little to show the relevance of chemistry to the world outside the laboratory.

One way to overcome these problems may be to introduce some course content relating chemistry to society but, as the examples in the anthology show, there is no agreement on the best way to do this. Complicating the matter is that secondary school students have relatively little science training to enable them to formulate their ideas about the relation of science and society. The terms "science" and "society" themselves have such diffuse meanings as to make worthwhile discussion difficult.

In order to impart relevance to chemistry courses without diluting the chemistry content, it is worthwhile to consider three types of material which might be included in secondary school curricula. First is the social background of scientific discoveries (the interactions of chemists involved in the development and refutation of discoveries). Second is the application of chemical processes in the local community. Finally, the course might consider the social responsibility of chemists, as individuals and as a group in society.

At present, there is little information available for teachers who might wish to include such material in their chemistry courses. The assembly of information and preparation of teaching guides is viewed as an important initiative: one in which the Committee on Teaching of Chemistry could play an important role.

A forum for users of chemical nomenclature

A symposium dealing with "THE USE OF CHEMICAL NOMENCLATURE" will serve as a forum for discussion on the use of chemical nomenclature, provide information on new developments, and stimulate feedback for IUPAC's nomenclature Commissions. Users of chemical nomenclature will be able to put their problems to leading experts in the field. Although the symposium is not IUPAC-sponsored, several key speakers will represent IUPAC groups active in formulation of nomenclature. Dr. Kurt Loening (Chairman of IUPAC's Interdivisional Committee on Nomenclature and Symbols) will talk about "Standardization in the Field of Chemical Nomenclature". Dr. H. B. F. Dixon (Secretary of the IUB-IUPAC Joint Commission on Biochemical Nomenclature) will speak of "Problems in the Field of Biochemical Nomenclature". The Vice-chairman of the IUPAC Commission on Nomenclature of Organic Chemistry, Dr. G. P. Moss, will chair a Group Meeting concerning educational aspects of nomenclature. "The Role of the UK in the Field of Chemical Nomenclature" will be discussed by Dr. Harold Egan (Secretary of the CHEMRAWN Committee and IUPAC representative to SCOPE, the Scientific Committee on Problems of the Environment). Dr. Egan is Director of the UK Laboratory of the Government Chemist, which is the main organizer of the symposium. The symposium will be held 24-26 March 1981 in London, UK.

**Chemical Education in the Seventies, edited by A. Kornhauser, C.N.R. Rao and D. J. Waddington. For details, see "Off the Press" in this issue.*

RECENT REPORTS

Use of abbreviations in the chemical literature. Prepared by David R. Lide, Jr., for the Interdivisional Committee on Nomenclature and Symbols. *Pure & Applied Chemistry,* 52, No. 9 (September 1980), pp. 2231-2232.

Present state of development in waste and waste water treatment techniques in the chemical industry and possible future trends. Prepared by K. Trobisch for the Commission on Water Quality. *Pure & Applied Chemistry,* 52, No. 9 (September 1980), pp. 2235-2251.

Atomic weights of the elements 1979. Prepared by N. E. Holden for the Commission on Atomic Weights and Isotopic Abundances. *Pure & Applied Chemistry,* 52, No. 10 (October 1980), pp. 2351-2384.

Nomenclature for thermal analysis, sections II and III. Prepared by G. G. Guilbault for the Commission on Analytical Nomenclature. *Pure & Applied Chemistry,* 52, No. 10 (October 1980), pp. 2387-2391.

Viscosity: Recommended reference materials for realization of physicochemical properties. Collated by T. Plebanski for the Commission on Physicochemical Measurements and Standards. *Pure & Applied Chemistry,* 52, No. 10 (October 1980) pp. 2395-2404)

CONFERENCES

IUPAC meetings are indicated in bold type
Additional information from address in parenthesis

1981

CHEMISTRY/LATIN AMERICA
February 1-7 14th Latin American Congress of Chemistry. San José, Costa Rica.
(G. M. Chaverri, Apartado 6852, San José, Costa Rica)

NUCLEOSIDES AND NUCLEOTIDES
February 4-6 4th International Round Table: Nucleosides and Nucleotides and their Biological Applications. University of Antwerp (RUCA), Belgium.
(Dr. E. Esmans, University of Antwerp (RUCA), Laboratory for Organic Chemistry, Groenenborgerlaan 171, 2020 Antwerp, Belgium)

TRACE ANALYSIS
February 16-19 International Symposium on Trace Analysis and Technological Development. Bombay, India.
(Dr. Gangadharan, Scientific Officer, Analytical Chemistry Division, BARC, Bombay-400 085, India)

FOOD CHEMISTRY
February 17-20 1st European Conference on Food Chemistry. Vienna, Austria.
(Euro Food ChemI, c/o, Verein österreichischer Chemiker, A-1010 Wien, Eschenbachgasse 9, Österreich, Austria)

HIGH TEMPERATURE CORROSION
March 2-5 Int. Conf. on High Temperature Corrosion. Scottsdale, Ariz., USA.
(Robert A. Rapp, Dept., of Metallurgical Engineering, Ohio State University, 116 West 19th Ave., Columbus, Ohio 43210, USA)

TOXICOLOGY
March 4-7 Int. Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity. Barcelona, Spain.
(Symposium on Chemical Indices and Mechanisms of Organ-Directed Toxicity, 142-144 Oxford Road, Cowley, Oxford OX4 2DZ, UK)

ANALYTICAL CHEMISTRY & APPLIED SPECTROSCOPY
March 9-13 32nd Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy. Atlantic City, New Jersey, USA.
(Pittsburgh Conference, 437 Donald Road, Pittsburgh, PA 15235, USA)

COLLOIDAL PARTICLE INTERACTIONS
March 16-21 Int. Symposium on Interaction of Particles in Colloidal Suspension. Canberra, Australia.
(Prof. B. W. Ninham, Dept. of Applied Mathematics, Institute of Advanced Studies, Australian National University, Canberra, ACT, Australia 2600)

CHEMICAL NOMENCLATURE
March 24-26 The Use of Chemical Nomenclature. London, UK.
(Symposium Organiser, Laboratory of the Government Chemist, Room 564A, Cornwall House, Stamford Street, London, S.E.1 9NQ, UK

ENERGY & ENVIRONMENT EDUCATION
March 26-31 Regional Seminar on Energy and Environment Education in Europe. Monte Carlo, Monaco.
(Ms. Sheila Hopkinson, Conference Secretary, British Council, 10 Spring Gardens, London SW1, UK)

AMERICAN CHEMICAL SOCIETY
March 29-April 3 181st National Meeting of the American Chemical Society, Atlanta, Georgia, USA.
(Mr. A. T. Winstead, American Chemical Society, 1155 - 16th Street N W, Washington DC 20036, USA)

BIOCHEMISTRY
March 29-April 4 14th Meeting of Federation of European Biochemical Societies. Edinburgh, Scotland.
(The Biochemical Society, 7 Warwick Court, London WC1R 5DP, UK)

ARID SOILS
March 29-April 4 Int. Conference on Arid Soils, Jerusalem, Israel.
(D. H. Yaalon, Dept. of Geology, The Hebrew University of Jerusalem, Jerusalem 9100, Israel)

OZONE
March 30-April 5 5th World Ozone Congress, Berlin, Federal Republic of Germany.
(International Ozone Association, Secretariat of European Committee, 9 rue de Phalsbourg, 75017 Paris, France)

BIOPHARMACEUTICS & PHARMACOKINETICS
April 1st European Congress of Biopharmaceutics and Pharmacokinetics. France.
(Faculté de Pharmacie, B.P. 38, 28 Place Henri Dunant, 63001 Clement-Ferrand Cedex, France)

PORTUGUESE CHEMICAL SOCIETY
April 4th Annual Meeting of the Portuguese Chemical Society. Lisbon, Portugal.
(Coordinating Committee of the 4th Annual Meeting Portuguese Chemical Society, Avª. DA REPÚBLICIA, 137-4°. 1000 Lisbon, Portugal)

BIOTECHNOLOGY
April 5-10 2nd European Congress on Biotechnology. Eastbourne, UK.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Sq., London SW1X 8PS, UK)

CONFERENCES 1981

POLYMERS

April 6-7 2nd European Conference on Polymers, plastics and polyurethanes. Glasgow, Scotland, UK.
(V. M. Bhatnagar, Alena Enterprises of Canada, POB 1779, Cornwall, Ontario K6H 5V7, Canada)

CORROSION

April 6-10 Int. Corrosion Conference. Toronto, Ontario, Canada.
(Conference Coordinator, NACE, POB 218340, Houston, Texas 77218, USA)

FLUID FLOW

April 6-10 2nd Int. Symposium on Flow: Its measurement & control in science and industry. St. Louis, Missouri, USA.
(Dr. G. E. Mattingly, Fluid Engineering Division, National Bureau of Standards, DC 20234, USA)

U.K. CHEMICAL CONGRESS

April 7-9 Chemical Society Annual Congress. Guildford, UK.
(Chemical Society, Burlington House, London W1V 0BN, UK)

METAL-HYDROGEN SYSTEMS

April 13-15 Int. Symposium on Metal Hydrogen Systems. Miami Beach, Florida, USA.
(Dr. T. Nejat Veziroglu, Director of Clean Energy Research Institute, University of Miami, POB 248294, Coral Gables, Florida 33124, USA)

ELECTROANALYSIS

April 13-16 Int. Symposium on Electroanalysis in Clinical, Environmental and Pharmaceutical Chemistry. Cardiff, Wales, UK.
(Electroanalysis Symposium, UWIST, Cardiff, CF1 3NU, Wales, UK)

MÖSSBAUER EFFECT

April 13-17 Int. Conference on the Application of the Mossbauer Effect. Srinagar, Kashmir, India. (Dr. V. G. Bhide, National Physical Laboratory, Hillside Road, New Delhi - 110012, India)

CHEMISTRY IN ASIA

April 23-25 1st FACS Regional Seminar "Priorities in Chemistry in development of Asia". Kuala Lumpur.
(Hon. Secretary, Malaysian Institute of Chemistry, c/o Rubber Research Institute of Malaysia, POB 150, Kuala Lumpur)

CHEMISTRY/ASIA AND PACIFIC

April 26-May 1 1st Asian & Pacific Chemistry Congress. Singapore.
(The Congress Secretary, 1st ISPAC Congress, Singapore Professional Centre, 129 B Block, Outram Park, Singapore 0316)

POLYMERS

April 29-30 International Conference on Polymers, plastics and polyurethanes. Montreal, Canada.
(V. M. Bhatnagar, Alena Enterprises of Canada, POB 1779, Cornwall, Ontario K6H 5V7, Canada)

TECHNOLOGY EXCHANGE

April 29-May 4 TechEx 81—Asia: 9th Annual World Fair for Technology Exchange. Sri Lanka.
(Dr. Dvorkovitz & Associates, POB 1748, Ormond Beach, FL 32074, USA)

CLINICAL PHARMACOLOGY

May 11th Int. Symposium on Clinical Pharmacology. Pisa, Italy.
(Prof. Dr. A. Bertelli, via Roma 55, Pisa, Italy)

AGGLOMERATION

May 6-9 3rd Int. Symposium on Agglomeration. Nürnberg, Federal Republic of Germany.
(Prof. O. Molerus, Institut fur Mechanische Verfahrenstechnik der Universitat Erlangen, Martenstrasse 9, D-8520 Erlangen, Federal Republic of Germany)

COPPER IN SOILS AND PLANTS

May 7-9 Golden Jubilee International Symposium on Copper in Soils and Plants. Perth, Western Australia.
(Prof. J. F. Loneragan, School of Environmental and Life Sciences, Murdoch University, Perth, Western Australia, 6153)

COORDINATION CHEMISTRY

May 10-14 10th Meeting of the Coordination and Metal Organic Chemistry Division of the Royal Australian Chemical Institute and the New Zealand Institute of Chemistry. Queenstown, New Zealand.
(Dr. J. Simpson, Department of Chemistry, University of Otago, POB 56, Dunedin, NZ)

SCIENCE/PACIFIC REGION

May 11-15 51st Congress of the Australian & New Zealand Association for the Advancement of Science. Brisbane, Queensland, Australia.
(N. Verney, ANZAAS-Queensland, GPO Box 2434, Brisbane, Queensland 4001, Australia)

LIQUID CHROMATOGRAPHY

May 11-15 5th Int. Symposium on Column Liquid Chromatography. Avignon, France.
(G. Guiochon, Ecole Polytechnique, Laboratoire de Chimie Analytique Physique, Route de Saclay, 91128, Palaiseau Cedex, France)

TRACE ELEMENT METABOLISM

May 11-15 4th Int. Conference on the Trace Element Metabolism in Man and Animals. Perth, Australia.
(Prof. Underwood, Univ. of Western Australia, Perth, W.A. Australia 6000)

CHEMICAL EDUCATION/AUSTRALIA

May 13-15 National Symposium on "The 1980's: A Challenge and Responsibility for Chemical Education. Bathurst, N.S.W. Australia.
(Mr. C. Fogliana, Secretary, Chemistry Education Division, RACI, C/- Science Department, Mitchell College of Advanced Education, Bathurst, N.S.W. 2795, Australia)

HETEROGENEOUS & HOMOGENEOUS CATALYSIS

May 25-27 3rd Int. Symposium on Relations between Heterogeneous and Homogeneous Catalysis. Groningen, Netherlands.
(Dr. R. S. Downing, Koninklijke/Shell-Laboratorium, Postbus 3003, NL-1003 AA Amsterdam, Netherlands)

CHEMISTRY/CANADA

May 31-June 3 64th Chemical Conference and Exhibition of the Chemical Institute of Canada. Halifax, Nova Scotia, Canada.
(The Chemical Institute of Canada, 151 Slater St., Suite 906, Ottawa, Ontario, Canada, K1P 5H3)

ACTIVATION ANALYSIS

May 31-June 4 6th Int. Conference on Modern Trends in Activation Analysis. Toronto, Ontario, Canada.
(Dr. R. E. Jervis, 6th MTAA Conference Convenor, Faculty of Applied Science and Engineering, University of Toronto, Ontario, Canada M5S 1A4)

MINERALOGY
June Int. Conf. on App. Mineralogy in the Mineral Industry. Johannesburg, South Africa.
(The Secretary, ICAM 81, Private Bag X3015, Randburg, 2125, South Africa)

ORGANIC CHEMISTRY
June 1-5 2nd European Symposium on Organic Chemistry. Stresa, Italy.
(Prof. Giorgio Modena, Istituto di Chimica Organica, Via Marzolo 1, Italy - 35 100 Padova)

PHOSPHORUS CHEMISTRY
June 1-5 Int. Conference on Phosphorus Chemistry. North Carolina, USA.
(Prof. Louis D. Quin, General Chairman, Paul M. Gross Chemical Laboratory, Duke University, Durham, N.C. 27706, USA)

FREE RADICALS
June 2-7 15th Int. Symposium on Free Radicals. Canada.
(Prof. W. E. Jones. Dept. of Chemistry, Dalhousie University, Halifax, Nova Scotia B3H 4T3, Canada)

ENERGY & COMPOSITE MATERIALS
June 3-5 2nd. Int. Symposium on Energy & Composite Materials. Venice, Italy.
(G. Bonavent, Institut Français de Pétrole, 1&4 Avenue de Bais-Preau, B.P. 311, F-92506 Rueil Malmaison, Cedex France)

FOOD TECHNOLOGY
June 3-5 European Symposium on Progress in Food Engineering. Milan, Italy.
(Simpsio "Progress in Food Engineering", Instituto di Tecnologie Alimentari, Via Celoria 2, 20133 Milan, Italy)

RUBBER CONFERENCE AND EXHIBITION
June 8-12 1981 Int. Rubber Conference and Exhibition. Harrogate, UK.
(RUBBERCON'81, Richard H. Craven, Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, UK)

WOOD AND PULPING
June 9-12 The "Ekman-days" Int. Symposium on Wood and Pulping Chemistry. Stockholm, Sweden.
(Dr. P. F. Nelson, Australian Paper Manufactures Ltd., Research Laboratory, 17 Rex Ave., Alphington, Victoria 3078, Australia)

TEXTILES & DYES
June 11-13 12th Congress of the International Federation of Associations of Textile Chemists and Colourists: The Future of the Textile Industry. Budapest, Hungary.
(The General Secretary, SODAC POB 244, Bradford, West Yorks, BD1 2JB, UK)

QUANTUM CHEMISTRY
June 14-19 4th Int. Congress on Quantum Chemistry. Topics: Quantum mechanical methods. Uppsala, Sweden. (Per-Olov Löwdin, 4th ICQC, Box 518, S-751 20 Uppsala, Sweden)

RUBBER & PLASTICS
June 25-26 International Conference on Rubber and Plastics. Copenhagen, Denmark.
(V. M. Bhatnagar, Alena Enterprises of Canada, POB 1779, Cornwall, Ontario, K6H 5V7, Canada)

BIOELECTROCHEMISTRY & BIOENERGETICS
June 27-July 2 6th International Symposium on Bioelectrochemistry and Bioenergetics. Kibbutz Kiryat Anarin, Israel.
(Mrs. R. Goldstein, Aharon Katzir Katchalsky Centre of the Institute of Science, Rehovot, Israel)

SURFACE AND COLLOID SCIENCE
July 5-10 4th Int. Conference on Surface and Colloid Science. Jerusalem, Israel.
(Prof. A. S. Kertes, Institute of Chemistry, The Hebrew University, Israel—Jerusalem)

MACROMOLECULAR CHEMISTRY
July 6-9 27th IUPAC Symposium on Macromolecular Chemistry. Strasbourg, France.
(Prof. P. Sigwalt, Laboratoire de Chimie Macromoléculaire, Tour 44, ler Etage, Université Pierre et Marie Curie, 4 Place Jussieu, F - 75230 Paris Cédex 05, France)

NMR SPECTROSCOPY
July 12-17 5th Int. Meeting on NMR Spectroscopy. Exeter, UK.
(UK Chemical Society, Burlington House, London W1V 0BN, UK)

POLYMER CHARACTERIZATION
July 13-17 Int. Symposium on Advances in Polymer Characterization. Durham, UK.
(Dr. W. J. Feast, Chemistry Dept., University of Durham, South Road, Durham DH1 3LE, UK)

NON-CONVENTIONAL ENERGY SOURCES
July 14-Aug. 6 2nd International Symposium on Non-conventional Energy. Topics include Solar Energy Fundamentals, Advanced solar energy technology, bioconversion, materials science for solar energy conversion and management of energy. Miramare-Trieste, Italy.
(International Centre for Theoretical Physics, POB 586, I-34100 Trieste, Italy)

CHEMOTHERAPY
July 19-24 12th Int. Congress of Chemotherapy. Florence, Italy.
(Prof. Dr. P. Periti, Viale Morgagni 65, 1-50134 Florence, Italy)

PHARMACOLOGY
July 19-24 8th Congress of the Int. Union of Pharmacology. Tokyo, Japan.
(Dr. F. Gross. Dept., of Pharmacology, University of Heidelberg, Im Neuenheimer Feld 366, D-6900 Heidelberg, Federal Republic of Germany)

PLATINUM GROUP METALS
July 19-24 Int. Conference on the Chemistry of Platinum Group Metals. Bristol, UK.
(Dr. P. L. Gogin, School of Chemistry, The University, Bristol BS8 1TS, UK)

VAPOUR GROWTH & EPITOXY
July 19-24 5th International Conference on Vapour Growth and Epitoxy. San Diego, CA, USA.
(Dr. D. W. Shaw, Texas Instruments, POB 225936, M/S 145, Dallas, TX 75265, USA)

DETERMINATION OF POLYMER STRUCTURE
July 20-23 22nd Prague Microsymposium on Characterization of Dynamic & Geometrical Structure of Polymer Systems by NMR Spectra. Czechoslovakia.
(B. Sedlácek, Institute of Macromolecular Chemistry, Czechoslovak Academy of Science, Heyrovskeho N.2, CS-162 06 Praha 616, Czechoslovakia)

CONFERENCES 1981

ORGANIC SYNTHESIS
July 20-23 7th Int. Symposium on Synthesis in Organic Chemistry. Oxford, UK.
(UK Chemical Society, Burlington House, London W1V 0BN, UK)

CAROTENOIDS
July 26-31 6th Int. Symposium on Carotenoids. Liverpool, UK.
(Dr. G. Britton, Dept. of Biochemistry, University of Liverpool, POB 147, Liverpool L69 3BX, UK)

SOURCES OF ENERGY
August United Nations Conf. on New & Renewable Sources of Energy. Nairobi, Kenya.
(Information Officer, DESI/DPI - room 1072-C, United Nations, New York, NY 10017, USA)

ORGANOMETALLIC CHEMISTRY
August 2-6 Int. Symposium on Organometallic Chemistry Directed to Organic Synthesis. Fort Collins, Colorado, USA.
(Prof. J. K. Stille, Dept., of Chemistry, Colorado State University, Fort Collins, Colorado 80523, USA)

CHEMICAL EDUCATION
August 9-14 6th Int. Conference on Chemical Education. Maryland, USA.
(Dr. Marjorie Gardner, Division Director, Division of Science Education Resources Improvement, National Science Foundation, Washington DC 20550, USA)

ORGANOMETALLIC CHEMISTRY
August 9-14 10th Int. Conference on Organometallic Chemistry. Toronto, Canada.
(Dr. H. C. Clark, Vice-President Academic, University of Guelph, Guelph, Ontario, Canada N1G 2W1)

PLASMA CHEMISTRY
August 10-14 5th Int. Symposium on Plasma Chemistry. Edinburgh, UK.
(Dr. B. Waldie, Chairman, Department of Chemical and Process Engineering, Heriot-Watt University, Chambers Street, Edinburgh EH1 1HX, UK)

IUPAC CONGRESS
August 16-22 28th IUPAC Congress. Topics are: Chemistry applied to energy problems, environment, upgrading of resources, computers, analytical chemistry, physical chemistry, inorganic chemistry, organic chemistry. Vancouver, Canada.
(IUPAC Congress Secretariat, c/o Chemical Institute of Canada, 151, Slater Street, Suite 906, Ottawa, Ontario K1P 5H3, Canada)

CRYSTALLOGRAPHY
August 16-25 12th Int. Congress of Crystallography. Ottawa, Canada.
(Mr. K. Charbonneau, Executive Secretary, 12th IUCr Congress, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6)

ATMOSPHERIC PHYSICS
August 16-29 Int. Association of Meteorology and Atmospheric Physics. Hamburg, Federal Republic of Germany.
(Mr. Stanley Ruttenberg, Secretary General IAMAP, National Center for Atmospheric Research, POB 3000, Boulder, Colorado 80307, USA)

HIGH PRESSURE
August 17-22 8th AIRAPT, 18th EHPRG Conference on High Pressure in Research and Industry. Uppsala, Sweden.
(Dr. Carl-Magnus Backman, Secretary, High Pressure in Research and Industry, 8th AIRAPT & 18th EHPRG Conference. Institute of Physical Chemistry, Box 532, S-751 21 Uppsala, Sweden)

ANALYTICAL STUDIES
August 20-21 Int. Symposium on Harmonisation of Collaborative Analytical Studies. Helsinki, Finland.
(Dr. H. Egan, Laboratory of the Government Chemist, Cornwall House, Stamford St., London SE1 9NQ, UK)

AMERICAN CHEMICAL SOCIETY
August 23-28 ACS Fall Meeting. New York City, USA.
(American Chemical Society, 1155 16th Street, NW, Washington DC 20036, USA)

EUROANALYSIS
August 23-28 4th FECS Euroanalysis Conference. Helsinki, Finland.
(Euroanalysis—IV, Association of Finnish Chemical Societies, Mr. Veikko Velamo, Executive Director, Pohj. Hesperiankatu 3 B 10, SF-00260 Helsinki 26, Finland)

CHEMISTRY/NEW ZEALAND
August 23-28 Golden Jubilee Conference. Auckland, New Zealand.
(Dr. D. J. McLennan, Chemistry Dept., University of Auckland, Auckland, New Zealand)

HETEROCYCLIC CONGRESS
August 23-28 8th International Congress of Heterocyclic Chemistry. Graz, Austria.
(Prof. Dr. Thomas Kappe, Institute of Organic Chemistry, University of Graz, Heinrichstr. 28, A-8010 Graz, Austria)

BIOCHEMISTRY/BIOPHYSICS
August 23-29 7th Int. Biophysics Congress and 3rd Panamerican Biochemistry Congress. Mexico City.
(Dr. Hugo Arechiga, Cerrada de Popocatepetl 51-A, Colonia General Anaya, Mexico 13, D.F., Mexico)

ORGANOSILICON
August 23-29 6th Int. Symposium on Organosilicon Chemistry. Budapest, Hungary.
(Prof. Tamás Székely, Chairman of the Organizing Committee, Research Laboratory of Inorganic Chemistry of the Hungarian Academy of Sciences, H-1502. Budapest, Pf. 132)

SOLAR ENERGY
August 24-28 Int. Solar Energy Congress. Brighton, UK.
(Prof. David Hall, University of London, Kings College, 69 Half Moon Lane, London SE24 9JF, UK)

DRUG RESEARCH
August 25-28 2nd IUPAC-IUPHAR Symposium on Strategy in Drug Research. Noordwijkerhout, Netherlands.
(Symposium Secretary, Dr. M. L. de Winter, Philips Duphar B.V., POB 2, NL-1380 AA Weesp, Netherlands)

HISTORY OF SCIENCE
Aug. 26-Sept. 3 16th Int. Congress of the History of Science. Bucharest, Romania.
(S. Balan, Romanian Academy of Science, Calea Victoriei 125, Set 1, Bucharest, Romania)

CONFERENCES 1981

AROMATIC COMPOUNDS

Aug. 30-Sept. 4 4th Int. Symposium on Chemistry of Novel Aromatic Compounds. Jerusalem, Israel. (Prof. I. Agranat, Department of Organic Chemistry, Hebrew University of Jerusalem, Jerusalem, Israel)

CLINICAL CHEMISTRY

Aug. 30-Sept. 5 11th Int. Congress of Clinical Chemistry. Vienna, Austria.
(Secretariat, 11th Int. Congress of Clinical Chemistry, 4th European Congress of Clinical Chemistry, POB 35, A-1095 Wien, Austria)

FERMENTATION TECHNOLOGY

Aug. 31-Sept. 3 3rd Int. Conference on Computer Applications in Fermentation Technology. Manchester, UK.
(Conference Secretariat, Society of Chemical Industry, 14 Belgrave Square, London SW1X 8PS, UK)

ORGANIC FREE RADICALS

Aug. 31-Sept. 4 3rd Int. Symposium on Organic Free Radicals. Freiburg, Federal Republic of Germany.
(GDCh, Box 90 04 40, D-6000 Frankfurt 90, Federal Republic of Germany)

HEAVY METALS

September International Conference on Heavy Metals in the Environment. Amsterdam.
(Secretariat, CEP Consultants Ltd., 26 Albany St., Edinburgh EH1 3QH, Scotland, UK)

HOT ATOM CHEMISTRY

September 11th International Hot Atom Chemistry Symposium. Davis, CA, USA.
(Prof. J. Root, Department of Chemistry, University of California, Davis, CA 95616, USA)

FOOD SCIENCE

September Symposium on the Role of Food Science in the Community (Int. Union of Food Science & Technology). Helsinki, Finland.
(Prof. P. Koivistoinen, Institute of Food Chemistry and Technology, Helsinki, Finland)

CHROMATOGRAPHY

September 1-4 3rd Danube Symposium on Chromatography. Siófok, Hungary.
(3rd Danube Symposium on Chromatography, c/o Hungarian Chemical Society, POB 240, H-1368 Budapest, Hungary)

ATOMIC SPECTROSCOPY

September 4-8 9th International Conference on Atomic Spectroscopy and 22nd Colloquium Spectroscopicum Internationale, Tokyo, Japan. (The Japan Society for Analytical Chemistry, 9th ICAS/XXII CSI, Gotanda Sanhaitsu, 26-2 Nishigotanda 1-chome, Shinagawa-ku, Tokyo 141, Japan)

METALLIC CORROSION

September 6-11 8th Int. Congress on Metallic Corrosion (ICMC). Mainz, Federal Republic of Germany.
(DECHEMA, 8th ICMC, Postfach 97 01 46, D-6000 Frankfurt/Main 97, Federal Republic of Germany)

PHOTOCHEMISTRY

September 6-11 10th Int. Conference on Photochemistry. Crete, Greece.
(Dr. P. M. Rentzepis, Bell Laboratories, ID 358, Murray Hill, New Jersey 07974, USA)

ANAEROBIC DIGESTION

September 6-12 2nd Int. Symposium on Anaerobic Digestion. Travemunde, Federal Republic of Germany.
(2nd International Symposium on Anaerobic Digestion, 142-144 Oxford Road, Cowley, Oxford, UK)

MATERIALS AT HIGH TEMPERATURES

September 7-10 The Chemistry of Materials at High Temperatures. A.E.R.E. Harwell, Nr. Didcot, Oxford, UK.
(Dr. P. E. Potter, Chemistry Division, A.E.R.E. Harwell, Didcot, Oxon, OX11 0RA, UK)

RADIOPHARMACOLOGY

September 9-11 2nd Int. Symposium on Radiopharmacology. Chicago, Illinois, USA.
(Pharmacology Department, School of Medicine, Loyola University, Maywood, Illinois 60653, USA)

MICROSCOPY OF COALS

September 14-16 Microscopy of Coals, Cokes, Carbon & Graphite. York, UK.
(Administrator, Royal Microscopical Society, 37/38, St. Clements, Oxford OX4 1AJ, UK)

BIO-CALORIMETRY

Sept./Oct. International Symposium on Bio-Calorimetry. Tbilisi, Georgian SSR, USSR. (Dr. P. G. Asatiani, Institute of Physics, Acad. Sci. GSSR, Guramishvili str. 6, 380077, Tbilisi, USSR)

CHEMICAL PHYSICS

October 1-7 Int. Symposium on Chemical Physics. Moscow/Yerevan, USSR. (Prof. N. M. Emanuel, Institute of Chemical Physics, Academy of Sciences of USSR, Vorobyevskoye Chaussee 2-b, SU-117334 Moscow, USSR)

CHEMICAL ENGINEERING

October 4-9 Interamerican Congress of Chemical Engineering. Montreal, Canada. (Canadian Society for Chemical Engineering, 151 Slater St., Suite 906, Ottawa, Ontario, Canada K1P 5H3)

WATER POLLUTION CONTROL

October 4-10 Water Pollution Control Federation Int. Convention. Detroit, Michigan, USA (R. A. Canham, 3900 Wisconsin Avenue, NW, Washington DC 20016, USA)

ENERGY/ASIA

October 7-9 Ascope 81: 2nd Asean Energy Conference. Manila, Philippines.
(ASCOPE 81, PNOC Building, 7901 Makati Avenue, Makati, Philippines)

CHEMASIA 81

October 21-24 2nd Asian International Chemical & Process Engineering & Contacting Show & Conference. World Trade Centre, Singapore.
(John Huang, Singapore Exhibition Services (pte) Ltd. 410 Cathay Building, Mount Sophia, Singapore 0922)

FUEL CYCLES

November 9-12 International Conference on Fast Reactor Fuel Cycles. London, UK.
(The Secretariat, British Nuclear Energy Society at the Institution of Civil Engineers, 1-7 Great George Street, Westminster, London SW1P 3AA, UK)

ENVIRONMENTAL POLLUTION

December 18-19 European Conference on Environmental Pollution. Frankfurt, Federal Republic of Germany.
(Alena Enterprises of Canada, POB 1779, Cornwall, Ontario, K6H 5V7, Canada)

OFF THE PRESS

Recent IUPAC publications

Tetraphenylborates
Volume 18: IUPAC Solubility Data Series

Tetraphenylborates, compounds containing the $(C_6H_5)_4B^-$ anion, are relatively new substances. The first to be synthesized appears to have been lithium tetraphenylborate in 1947. Soon after, sodium tetraphenylborate was synthesized in the same laboratory. Both lithium and sodium tetraphenylborate are appreciably soluble in water, and soon attracted the attention of chemists as a precipitating agent for the potassium ion. The fact that $KB(C_5H_5)_4$ is, by far, the least soluble potassium salt in water was probably the most important factor leading to widespread interest in the tetraphenylborate ion and provided impetus to early research on tetraphenylborate as an analytical reagent.

The discovery that rubidium, cesium, thallium(I), silver and a variety of ammonium ions formed insoluble tetraphenylborates soon led to extensive use of tetraphenylborate as an analytical reagent for quantitative determination of these cations. For early development of gravimetric and other analytical procedures, the main emphasis was on completeness of precipitation and thermal stability of the precipitates. The exact solubilities of tetraphenylborates were incidental to the development of these techniques, and much of the early solubility data was of low accuracy or a qualitative estimation of order of magnitude.

In the 1960's, interest in tetraphenylborates was rekindled when it was found that the compounds had other useful applications. The tetraphenylborate ion acquired the status as a "reference" ion for a variety of physicochemical purposes. For these applications, accurate solubility data is required. To compile all available data, Prof. Orest Popovych has made an exhaustive search of the literature and collected solubility data for each tetraphenylborate in aqueous, organic and mixed solvent systems. Each solute-solvent system is critically evaluated, paying particular attention to purification and equilibrium.

The resulting hardcover volume of solubility data will contain about 260 pages. Scheduled for publication in March 1981, it will be available from Pergamon Press at a cost of US$100 or £50.

Chemical education in the seventies

This anthology contains contributions from 40 countries outlining developments in chemical education in schools, colleges and universities during the five years 1973-77. It highlights major innovations and new programmes in chemical education during this period.

Contributors were invited to prepare their reports to relate to one of the anthology's four sections; (1) Primary and secondary school level education, (2) College and university level education, (3) Training in the chemical and closely-related industries, and (4) Chemistry and society. The anthology also contains an article reviewing the reports (written by D. J. Waddington) and one looking towards the future (by A. Kornhauser).

The text provides a forum for the exchange of information about recent changes in curricula, assessment techniques, and other important aspects of chemistry teaching.

Preparation of the anthology was sponsored by the IUPAC Committee on Teaching of Chemistry (CTC), and edited by Professors A. Kornhauser, C.N.R. Rao and D. J. Waddington with a foreword by IUPAC President Zollinger.

The anthology may be purchased (for US$13.50 or £6, including postage and packing) from Prof. D. J. Waddington, Department of Chemistry, University of York, Heslington, York YO1 5DD, UK (make cheques payable to IUPAC CTC), or may be purchased from Pergamon Press.

Coordination Chemistry

An overview of modern research in coordination chemistry and organometallic chemistry is presented by this collection of plenary lectures from the 21st International Conference on Coordination Chemistry (held 7 - 11 July 1980 in Toulouse, France). The general theme of the papers is the structure, properties and applications of coordination compounds. Individual topics covered include the electronic structure of coordination compounds, unusual physical properties of coordination compounds in the solid state, coordination chemistry in solution, ligand reactivity in transition metal complexes, and application of coordination chemistry in biology.

The 15 papers contained in the volume include lectures by F. A. Cotton (Coordination compounds with metal - metal bonds), H. B. Gray (Solar energy storage reactions involving metal complexes), M. L. H. Green (The reactivity of simple hydrocarbon ligands attached to transition metals), and L. M. Venanzi (Transition metal hydrides as intermediates in organometallic reactions).

Containing about 200 pages and providing approximately 500 literature references, Coordination Chemistry—21 is scheduled for publication in March 1981. The hardcover volume will cost about US$50 or £22.50.

IUPAC Publications are available from the publisher, Pergamon Press, to whom orders should be addressed. Pergamon Press has six distribution centres throughout the world.

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The International Union of Pure and Applied Chemistry (IUPAC), formed in 1919, is a voluntary, non-governmental, non-profit association of organizations, each of which represents the chemists of a member country.

Its objectives are:
to promote continuing co-operation among the chemists of the member countries;
to study topics of international importance to pure and applied chemistry which need regulation, standardization, or codification;
to co-operate with other international organizations which deal with topics of a chemical nature;
to contribute to the advancement of pure and applied chemistry in all its aspects.

The membership of IUPAC presently comprises 43 countries, each represented by a national organization, such as an academy of science or research council.

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